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Designing Everyday Computational Things

Doctoral Dissertation

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Abstract

The prospect of ubiquitous computing in everyday life urges us to raise basic design issues pertaining to how we will *live* with, and not only use, computers. To design for everyday life involves much more than enabling people to accomplish certain tasks more effectively, and therefore, traditional approaches to human-computer interaction that focus on usability are not sufficient. To support critical discussion of, and reflection upon, the design of everyday computational things, both new design philosophies and a richer collection of design examples are needed.

This thesis reports on the development of a design philosophy based on investigations of the design space of everyday computational things. Using experimental design, a collection of design examples illustrating how computational things can become integral parts of everyday environments has been developed. These investigations have been centred on: amplification of things and environments using computational technology; different forms of information presentation; the use of everyday materials in the design of computational things; and the aesthetics of computational things in use.

The specific results are a number of design examples, including support for local interaction, access to digital information using physical objects as *tokens*, information displays such as the *ChatterBox* and *Informative Art*, and examples of *Slow Technology*. The general results are presented as a design philosophy for everyday computational things. This design philosophy is aimed at design for meaningful *presence*, rather than efficient use, and states that computational technology is a design material, that time is the central design parameter and that aesthetics is the basis for design for presence.

Keywords:

Human-computer interaction, interaction design, design research, experimental design, ubiquitous computing, aesthetics.

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Cover: Detail from photo of the *Fan House*.

Note: a digital version of the thesis in full colour is available at http://www.viktoria.se/~johan/thesis/ This web-page also includes errata and links to additional material, such as video clips of the design examples.

TOWARDS A DESIGN PHILOSOPHY FOR EVERYDAY COMPUTATIONAL THINGS

johan redström

1 Introduction

Everyday things are the things we live with. They are the building blocks of our lifeworlds. Many everyday things are not specifically for work or leisure, as they transcend the borders of many activities. Consider, for instance, the use of telephones: we use them at work to coordinate and communicate, but we also use them to talk to friends and familiy. In the case of mobile phones, this is even more evident as we carry the very same device with us, independent of whether we are working, spending time with friends, travelling, etc. As the mobile phone has entered our everyday life, it has also become a personal object that we use to express who we are, our lifestyle, etc. (cf. [50, 79, 82]).

The mobile phone is just one example of how computational things increasingly pervade everyday life. Computers are embedded in all sorts of existing kinds of things, such as cameras, cars and watches, transforming and amplifying their original appearances and functionalities. Computational technology is also used to realise a plethora of new kinds of devices such as video games, PDAs (Personal Digital Assistants), and musical instruments, the list being made longer each day. As computers pervade everyday life, they too will become everyday things.

What an everyday computational thing is, can not be captured by reference to distinctions such as office applications (e.g. word-processors) vs. games, or productive work vs. passive consumption, since such distinctions fail to acknowledge the complexities and subtleties of everyday life. Further, as use of information and communication technology increases and the importance of colocation in space and time for collaboration and communication is reduced, divisions between work and spare time based on locations in space (e.g., offices) and time (e.g., business hours) are undermined. Instead of thinking about computer use in terms of work or play, the development towards a ubiquity of computational things in everyday life urges us to revisit the basic question of what computational things are in respect to how we are going to *live* with them. This question is the topic of this thesis.

Traditionally, human-computer interaction research tended to focus on how to effectively support people in accomplishing, primarily work-related, tasks, and therefore the notion of usability was central. As computational things become everyday things, what we design for can not be restricted to how to enable people to become more productive. Thus, there is a need for complementary design philosophies. The ambition of this thesis is to support the development of such new design philosophies and perspectives.

This thesis is an investigation of the design space of everyday computational things starting from the question of how to design such things so that they can become integral parts of everyday environments. Using experimental design, I have investigated how to design computational things for meaningful presence in everyday life, how to work with time as a central design variable, how to combine computational technology with traditional materials used in interior design. I have worked with how to design for different aspects of use, especially the aesthetics of things in use. The specific results from this investigation are the design examples described in the seven papers included in the thesis. These design examples illustrate a set of parameters, and design opportunities, of this design space, and they can be said to act as a kind of "landmarks". The more general results of this investigation are formulated as a design philosophy for everyday computational things. This design philosophy is described towards the end of this paper.

In the following, I will introduce the thesis by first describing its background in relation to two different lines of critique of present-day human-computer interaction. The first critique concerns the design of the human-computer interface itself and how computational technology can be integrated with everyday environments. The other concerns problematic consequences of a strict focus on usability, and what other values and aspects of use we have to acknowledge when designing for everyday life.

2 Background

The development of computer use can be described as a development towards ubiquity. First, very few computers existed and many people shared each one. Over time, this condition has changed and today, one user frequently confronts many computers and may even regularly use a collection of more or less specialised computational devices such as stationary and mobile PCs (Personal Computers), PDAs (Personal Digital Assistants), digital cameras and video games.

The design of how computational things appear *in use* has been centred on the notion of a human-computer interface, an interactive "surface" through which the user controls the computer and the results of the computations are displayed. As new areas of computer use have developed, new human-computer interfaces have been created to meet new demands (cf. [36]). Over time, new disciplines and research areas related to human-computer interaction (HCI) have emerged, e.g., *interaction design* as a response to new design challenges (cf. [89]) and *Computer-Supported Cooperative Work* (CSCW) as a response to the focus on single users within HCI in settings where the social and organisational context of computer use have become increasingly important (cf. [11]).

The human-computer interface is frequently referred to as the “user interface”, the reason being that it was just yet another interface between components of the system that had to be designed [37]. As we leave an engineering perspective and focus on people and their use of computers, this terminology is, however, no longer adequate. Grudin states that “Ironically, “user interface” is a technology-centered term. /.../ The computer is assumed, the user must be specified /.../ *The term “user” retains and reenforces an engineering perspective*” [37, p. 270].

Given the development of information technology during the last decade it is remarkable that little has changed since Grudin made his analysis over ten years ago. Not only is the term “user interface” still in use, but so is the perspective it reinforces, as can be seen in this quote from *User and Task Analysis for Interface Design* by Hackos and Redish:

> It is from work in cognitive psychology over the last several decades that we have come to appreciate that we cannot just impose designs on users. People are active parts of the system, and because they are much less predictable and less well understood than the computers and other technological parts of the system, they require even greater study and understanding. [38, p. 15].

Intitially, computers were a scarce resource and users literally had to come to the machine. The situation we face today is, however, quite different. It is important that we do not continue to regard the user as yet another part of some technical system, but instead consider computational things to be part of a larger context, in this case everyday life. This means that we have to revisit issues in both the design of computational things and how they will be used.

2.1 Ubiquitous Computing

> The significant universal tool of computer culture is the electronic screen. The screen is the pet of computer culture – at home as well as in the office. The television screen has developed into the universal communication medium of the information age, the screen is the paper of the Gutenberg age. Its applications are more or less unlimited. *Leopoldseder* [51, p. 69].

As screen-based interaction with computers still dominates, this statement is probably as relevant today as when it was made by Leopoldseder fifteen years ago. Comparisons between literacy technologies and computers have, however, also been used to illustrate the shortcomings of present human-computer interaction. Weiser comments that:

> Not only do books, magazines and newspapers convey written information, but so do street signs, billboards, shop signs and even graffiti. Candy wrappers are covered in writing. /.../ Silicon-based information technology, in contrast, is far from having become part of the environment. /.../ The state of the art is perhaps analogous to the period when scribes had to know as much about making ink or baking clay as they did about writing. The arcane aura that surrounds personal computers is not just a "user interface" problem. [83, p. 933].

What makes literacy technology so different from computational technology is, according to Weiser, how little effort it takes to use it: it is just there as a part of everyday things and environments, without demanding our attention [83]. In the case of literacy technology, the technology itself has "disappeared". (One should, however, not forget that it took us many years of hard training to develop these skills.) Making computers disappear, however, implies a reconsideration of many aspects of their design: "Getting the computer out of the way is not easy. This is not a graphical user interface (GUI) problem, but is a property of the whole context of usage of the machine and the attributes of its physical properties: the keyboard, the weight and desktop position of screens, and so on." [84, p. 76]. Similar views have been developed elsewhere, especially within the areas of *augmented reality* [88], *tangible user interfaces* [46] and more recently in the notion of *information appliances* [67].

A program for how to make computing an integral, invisible part of people's lives, called *ubiquitous computing,* was developed by Weiser and colleagues at Xerox PARC in the late 1980s [83, 87]. One of their hypotheses was that to effectively become part of the environment, computers have to be sensitive to where they are located, who is using them and similar issues related to context [cf. 80]. The first devices that came out of the ubiquitous computing experiments were the *tabs*, *pads* and *boards* [80, 83, 84]. They correspond to different sizes of commonsense objects: objects that fit in the hand (tabs), objects that can be carried around, e.g., about the size of scratchpad or a book (pads); and objects that are stationary resources, such as wall-mounted boards (boards).

The tabs, pads and boards were designed for different forms of reading and writing information: the tabs for easy information retrieval and writing short messages while on the move; the pads for, e.g., desktop use: the user would have several pads around, just like we are used to work with several paper documents, books, scratchpads, etc., simultaneously; and the boards, finally, as counterparts to bulletin boards, white boards and other similar surfaces that we use for public information distribution and collaboration.

The tabs, pads and boards used different forms of GUIs, but over time other approaches to interface design, such as *Calm Technology* [85, 86], were developed. Central to the notion of calm technology is the idea of periphery and peripheral attention. A characteristic property of peripheral information sources is that we can move our attention to them when needed in a seamless, and to some extent even unconscious, fashion (cf. also [12]). With calm technology, this vision of ubiquitous computing involved considerations on all levels of design ranging from hardware to the aesthetics of computational things in use.

Ubiquitous computing as a term was, at least initially, associated with these projects at PARC, but it is increasingly used as a general term for the research field that these ideas generated (cf. [35]). Other related terms are, for instance, *pervasive computing* [3], *sentient computing* [44], *invisible computing*[67], and *disappearing computing*[1]. The ubiquitous computing experiment at Xerox PARC represents one of the first reconsiderations of what computational things are and how to go about designing them, but there have also been other approaches to design for "ubiquitous computing" in the broad sense of the word.

Augmented-reality starts from a view similar to that of Weiser's vision of ubiquitous computing: instead of bringing people to the computers, be it a desktop computer or a VR (Virtual Reality) system, we should integrate computational technology with existing things and environments [88]. One common approach is to use overlay technology, such as see-through head-worn displays, to superimpose graphical information on the physical objects the user looks at (cf. [30, 71], also *wearable computing* [60]). In this way, physical objects can appear to have new (visual) properties, virtual objects can be added, etc. We might say that since the computer is only used as augmentation, it will not be a part of the real-world, but rather as a layer between people and the rest of the environment (cf. [29]). When used in the right context, the possibility of not having to change the properties of the real-world objects can be a way of introducing computational support into a practice by means of augmenting existing tools rather than replacing them. This strategy have been used

1. In 2000, a research agenda called *The Disappearing Computer* was initiated within the European Union research framework for Future and Emerging Technologies. For more information see "The Disappearing Computer, Information Document, IST Call for proposals, February 2000" (http://www.cordis.lu/ist/fetdc.htm).

in the development of computer support for work practices that have little room for error and breakdowns, such as air traffic control [59], where the so-called "flight strips" used for keeping track of aeroplanes where augmented rather than replaced with digital counterparts.

Besides giving computers access to rudimentary information about where they are located, who are using them, etc. the idea with *context-aware* (cf. [80]) computing is to make it possible for computing systems to infer what the user is doing so that he or she does not have to attend to the machine at all times commanding it what to do next (cf. [52]). Rekimoto and Nagao argue that:

> GUIs can reduce the cognitive overload of computer operations, but do not reduce the volume of the operations themselves. /.../ The user's focus of interest is not the human-computer interactions, but the human-real world interactions. /.../ Consequently, the reduction of the amount of computer manipulation will become an issue rather than simply how to make existing manipulations easier and more understandable. [71, p. 29].

To address this problem, they propose an interaction style called "Augmented Interaction" that "aims to reduce computer manipulations by using environmental information as implicit input." [71, p. 30]. Such implicit input will be gained by using various sensor technologies, such as camera vision, to infer what the user is currently doing. Such use of sensors is also central in the related areas of *intelligent* [13], *reactive* [15] and *responsive environments* [27].

The notion of *tangible user interfaces* represents another critique of GUIs and the personal computer (cf. [78]). Early examples include work on *graspable interfaces* [31] and experiments with tangible user interfaces at Interval [14]. Ishii and Ullmer present a design program for "tangible bits" [46] that states that "Ultimately, we are seeking ways to turn each state of physical matter – not only solid matter, but also liquids and gases – within everyday architectural spaces into "interfaces" between people and digital information." [46, p. 235]. Thus, tangible interfaces aims to literally turn the physical world into an interface, and to make computational resources available in a way that enables us to use the skills we have developed for manipulating ordinary physical objects. We also find the notion of foreground and background in this design program for tangible bits: with tangible interfaces we will be able to grasp & manipulate "foreground bits" coupled to physical objects, and to be aware of "background bits" through *ambient media* [46 p. 235] (cf. also [91]).

The concept of *information appliances* [67] is closely related to the idea of replacing the computer with a number of highly interconnected specialised devices in the ubiquitous computing scenario above. Norman argues that what makes the personal computer so complex and difficult to use is that it aims to do too many things for too many different users. By replacing the universal computer with information appliances optimised for a single task or activity, we can overcome many (if not most) of the usability problems associated with computers [67]. To get more complex functionality, users should be able to combine the functionality of several appliances, hence the need for communication between them. Given the difficulties associated with programming and managing our existing electronic appliances, such as video recorders, television sets and mobile phones, this solution might not be as simple to implement as it might first seem. Nevertheless, if we move beyond usability considerations, the concept of information appliances can be an interesting basis for reconsidering what computational things might be like (cf. [34]).

The approaches described above are all examples of how the personal computer and present interaction design have been challenged, and how computers instead can be made part of everyday environments. Designing everyday computational things is, however, not only a matter of making the interface reach out into the world, but also a matter of what we consider computer use to be about.

2.2 Use and Usability

When we describe or denote an everyday thing, we often do this on the basis of its practical functionality, e.g., a sail-boat, or a rain-coat. Even extreme designs of utility things with very limited practical functionality in actual use, are still defined by their "functionality" and it is this "functionality" that is the basis for the design. Part of the ambition in experimental design is to stretch the notion of what a given kind of thing, e.g., a house, is by exposing certain aspects of what we think it is and see how far one can go before the designed thing is no longer considered such a thing but something else. While practical use is a useful way to point out a place or a role of an artefact, it does not imply that practical functionality is all that matters.

Paulsson & Paulsson discuss three forms of use of utility things that the designer has to acknowledge: i) *practical* use; ii) *social* use; and iii) *aesthetic* use [68]. Practical use is for instance when we use a hammer to drive a nail, or when we use a car to take us somewhere. Unlike most hammers, cars also have strong symbolic values in social use. Social use concerns the roles things play in our social life, their symbolic values in social contexts[2], as when we choose to wear certain clothes for a particular occasion, e.g., at a wedding. Finally, aesthetic use concerns reflective use, e.g., when we observe a thing for its beauty. Aesthetic qualities cuts across both practical and social use as it concerns how we turn to a thing and reflect upon its expressions. These distinctions do not have to be made in terms of use; we can also distinguish between functional, symbolic and aesthetic *qualities* in use (cf. [20]).

Another way of describing similar aspects of the design of a utility thing, is to use the notions of product and meta-product. According to Monö, a meta-product is the result of "all the interpretations and ideas

2. This notion of symbolic properties should not, however, be confused with product semiotics, where semiotics is used in design to analyse how a certain design is perceived and understood (cf. [63]).

‘behind’ the physical product, such as prejudices, status, nostalgia, group affiliation and so on.” [63, p.20]. In our culture, the meta-product is made increasingly important, e.g., when we pay more for a certain brand [63, p. 20]. In Monö’s description of semiotic design, aesthetics is said to be “*the study of the effect of product gestalt on human sensations.*/…/ the way in which parts are made into a whole with the desired effect on human sensations. As a result, the aesthetics of design also comprises the study of the way in which human beings read and understand how to interpret the parts and the whole of a visual gestalt.” [63, p. 27]. Here, aesthetics is one of the factors that determine the consistency of the appearance of a thing.

In his analysis of design as rhetoric, and the designed object as argument, Buchanan discusses three aspects of the design argument: *logos*, *ethos*, and *pathos* [8]. Logos is technological reasoning, “the way the designer manipulates materials and processes to solve practical problems of human activity.” [8, p. 96]. For instance, most hammers are based on the basic premise of a lever supporting a head, made in a size fitting comfortably in a person’s hand. Ethos is the character of the designed product, as it reflects its maker: “part of the art of design is the control of such character in order to persuade potential users that a product has credibility in their lives” [8, p. 101]. Pathos, finally, concerns emotional persuasion and can be considered the connection between design and fine arts. Emotional persuasion is often in focus when we think about “form”, e.g., persuasion in terms of “beautiful” or “artful” design (cf. [8, p. 103]).

Although these three perspectives on design have their origins in such diverse design philosophies as the *Scandinavian Modern* design [68], *semiotic* design [63] and contemporary design theory [8], they all acknowledge a basic set of functional, social and aesthetic qualities of an artefact. We can now compare this to how design is approached in human-computer interaction.

Usability

Considering the use of computers as approached in HCI, the notion of *usability* is central. Definitions of usability vary, but the following five attributes can be considered typical [65, p. 26]:

- Learnability
- Efficiency
- Memorability
- Errors
- Subjective Satisfaction

Here, learnability means that a system should be easy to learn and that the learning curve should be appropriate, i.e., that novice users quickly can begin to work with the system and that the learning curve is smooth and does not pose large steps that are hard to overcome. Efficiency is about maintaining a high degree of productivity once the system has been learned. Memorability is about how easy it is to remember how to use the system once learned. For instance, systems that are only used a few times a year must be easy enough to memorise so that the user does not have to learn everything over again every time the system is going to be used. Further, the system should be designed in a way that minimises the number of errors users make, and in case an error occurs, recovery should be quick and easy. Finally, the system has to be satisfying to use; the user should like to use it.

As a comparison, we can consider the ISO 9241-11 definition of usability in the "ergonomic requirements for office work with visual display terminals" ([47], adopted from [32]):

- *Effectiveness*: the accuracy and completeness with which users achieve certain goals;
- *Efficiency*: the relation between effectiveness (as defined above) and the resources expanded in achieving them;
- *Satisfaction*: the user's comfort with and positive attitudes towards the use of the system.

In the actual practice of interaction design, usability is not necessarily restricted to these attributes and so neither list should be seen as exhaustive. However, it gives a general idea of how computer use is approached, what criteria are used to determine the quality of a design and that the underlying premise is how to make people more productive. Hackos and Redish state that “good design is important. It makes users happy and productive, increasing customer satisfaction, one of the major goals for most companies. It increases efficiency and decreases support calls, thus making and saving money for companies.” [38, p. 1]. Here, usability as a way of evaluating a design is clearly related to productivity.

Computer Use Revisited

It is obvious that the usability approach to design leaves out aspects of use that are acknowledged in other areas of design for everyday life. In fact, the basic premise of technology use as a way of increasing productivity, is in many respects incompatible with everyday life. Djajadiningrat et al. argues that “While usability is often a laudable goal, it isn’t enough. Focusing on ease of use tends to encourage a narrow view of what ‘use’ is with respect to technology, emphasising efficiency and productivity over exploration or curiosity. With a correspondingly narrow range of models for usability, interaction tends to be self-similar, mundane, and ultimately boring.” [22, p. 66]. The importance of “subjective satisfaction” in usability studies also indicates the relevance of a broader view on use. Hassenzahl et al. [39] report findings that indicate that “hedonic qualities”, such as novelty and originality, can be as important as ergonomic qualities, such as simplicity, in determining a software’s appeal to the user.

In *The Design of Everyday Things* Norman states that: ”If everyday design were ruled by aesthetics, life might be more pleasing to the eye but less comfortable; if ruled by usability, it might be more comfortable but uglier. If cost or ease of manufacture dominated, products might not be attractive, functional, or durable. Clearly, each consideration has its place. Trouble occurs when one dominates all the others." [66, p. 151]. Norman's remark suggests a very simplified notion of what design is about, and especially what aesthetics is about. In comparison, Borgmann argues that:

> /.../ design as a practice has divided into an engineering branch and an aesthetic branch. Engineering devises the ingenious underlying structures that disburden us from the demands of exertion and the exercise of skills and leave us with the opaque and glamorous commodities that we enjoy in consumption. Aesthetic design inevitably is confined to smoothing the interfaces and stylizing the surfaces of technological devices. Aesthetic design becomes shallow, not because it is aesthetic, but because it has become superficial. It has been divorced from the powerful shaping of the material culture. Engineering has taken over the latter task. But it in turn conceals the power of its shapes under discreet and pleasant surfaces. If we are concerned to revive engagment, we must try to recover the depth of design, that is, the kind of design that once more fuses engineering and aesthetics and provides a material setting that provokes and rewards engagement. [7, pp. 15f].

Part of the problem with the role of aesthetics in technology development is that aesthetics is often reduced to a matter of how a given thing "looks" on the surface. If we are interested in designing consistent and convincing things, things that have "depth" [7], we must consider aesthetics to be something much more profound. Zaccai argues that: "the original meaning of aesthetics must be rediscovered. We need to understand that aesthetics is not simply a visual exercise, but rather the appropriate and harmonious balancing of all user needs and wants within technical and social constraints." [93, p. 6], and further that "At a certain point the seemingly divergent requirements of technical rationalism, emotional content, and sensory perception converge and complete a sphere. It is that sphere which defines the true nature of aesthetics" [93, p. 9]. Crampton Smith and Tabor present a related perspective on the role of aesthetics in design:

> Aesthetics, moreover, are concerned with more than visual appearance. There is a delight in a program that is rigorously consistent, elegantly clear and lean, where sound and vision are perfectly at one, or where the representation chosen neatly fits the ways that users think about what they are doing. These qualities cannot be added on at the end: They are integral to the design and engineering of the product. [16, p. 45].

Aesthetics is not a matter of how to create a stylish surface of some artefact – it is one of the foundations for design. Design of computational things can, therefore, not be reduced to a matter of aesthetics vs. usability. We can not develop computational things with focus on practical functionality only and then add aesthetic, social, emotional etc. qualities afterwords – such dimensions of everyday things have to be made integral parts of our design approach from the start.

Despite the problematic lack of attention to aspects of use of everyday things that fall outside practical functionality and usability, this does not seem to be something that the HCI research community is going to reconsider in the near future. In *Strategic Directions in Human-Computer Interaction* [64], based on the results of the Human-Computer Interaction Working Group of the ACM Workshop on Strategic Directions in Computing Research, the field of HCI including future strategic themes are outlined. The strategic themes presented are: i) universal access to large and complex distributed information; ii) education and lifelong learning; iii) electronic commerce; iv) end-user programming; v) information visualisation; and vi) computer-mediated communication [64, pp. 800-802].

One of the technological trends identified is new forms of computational devices and ubiquitous computing. Among the HCI problems in ubiquitous computing presented, we find issues such as how to address "the tension between the design of interfaces appropriate to the device in question [size and resolution of display, stance of the user, e.g., sitting, standing, etc.] and the need to offer a uniform interface for an application across a range of devices. [e.g., to quickly learn to use a familiar application on a new device]" [64, p. 803]. With the possible exception of electronic commerce – as it is said to involve social issues such as trust and privacy – only the practical functionality and usability of computational things are considered. In the concluding section of the report, the authors state that: "We now have a solid foundation of principles and results to teach in courses and from which to base today's user interface design and tomorrow's research. As computing systems become increasingly central to our society, HCI research will continue to grow in importance." [64, p. 806]. While this design philosophy has been highly successful in some areas of computer use, this does not imply that it is universal.

This narrow perspective on the use of computational artefacts that, presumably, will be designed to be a part of people's everyday lives, is, unfortunately, also evident in the agendas of novel approaches such as ubiquitous computing. For example, in *Charting Past, Present, and Future Research in Ubiquitous Computing* by Abowd and Mynatt [1], the concept of "everyday computing" is presented and we learn that the following features of informal and daily activities will have to be addressed in future research: that i) they rarely have a clear beginning or end; ii) interruption is expected; iii) multiple activities operate concurrently; iv) time is an important discriminator; v) associative models of information are needed [1, pp. 42-44]. Among the future research directions that the authors think are needed, we find: how to vi) design a continuously present computer interface; vii) presenting information at different levels of the periphery of human attention; ix) connecting events in the physical and virtual worlds; x) modifying traditional HCI methods to support designing for informal, peripheral, and opportunistic behaviour [1, pp. 45-46].

While these issues all can be considered relevant, this agenda is also an illustration of the difficulty of turning away from a productivity oriented perspective on computer use. Abowd and Mynatt consider social issues in ubiquitous computing important, but their concern seem to be limited to aspects such as security, visibility, control and privacy in an environment where computers use sensors and automatic capture to become "context-aware". Although the authors aim to introduce the notion of "everyday computing", aspects of use that are crucial in other areas of design for everyday life are missing in this agenda.

It is obvious that technological development is ahead of the understanding of technology use. This is not too surprising given the history of technology-centred development. What is intriguing, however, is that a research discipline devoted to developing human-centred systems has paid so little attention to aspects of use that falls outside a concern for increased productivity. While the desktop computing paradigm has been challenged in a multitude of ways, we see little development in the understanding of what it means to have computational things present in our everyday lives. There are, however, examples of how to break away from this perspective on computer use.

Dunne argues that "The result [of the Human Factors approach to design], as the computer industry merges with other industries, is that the optimisation of the psychological fit between people and electronic technology, for which the industry strives, is spreading beyond the work environment to areas such as the home which have so far acted as a counterpoint to the harsh functionality of the workplace." [23, p. 18]. According to Dunne, this is due to uncritical acceptance of the "American Ideology" and the idea that all problems are "technical" problems and subject to rational solution through the accumulation of objective knowledge with a general ambition of maximising society's productivity and making the most economic use of its resources (cf. [23, p. 17]). To open up for new perspectives on electronic products and reduce this tight "psychological fit", Dunne has explored the notion of "parafunctionality", a kind of "functional estrangement" by means of creating a "poetic distance" towards the object [23, 75].

Another set of examples of new possibilities in the design space of everyday computational things are the conceptual information appliances presented in [34]. Here, Gaver and Martin criticise present design of everyday computational things: "Suggestions for how digital technologies might be employed in everyday settings tend to represent a narrow range of cultural possibilities, reinforcing a simple dichotomy between work and play. Many devices import values from the workplace into the home, emphasising the requirements of "domestic work" by allowing chores to be done more efficiently or productively. Others emphasise the desirability of taking "time off", allowing people to play unproductive games or access new forms of broadcast media. Other values seem rarely to be addressed at all." [34, p. 209]. The information appliances presented are instead designed to uncover new places for technology in everyday life by exploring different values, emotions and desires. Examples include the *(De)tour Guide*:

> The Guide would permit a variety of functions, from leading users to a designated location to encouraging them to become totally lost in unfamiliar districts. [34, p. 210].

Another proposal is the *Dawn Chorus*:

> It is pleasant to be awakened by the sound of local songbirds, but how much more enjoyable it would be if they knew our favourite music. This could be made possible by an artificially intelligent birdfeeder. Joining a microphone, speaker, pitch-tracker, and software, it would use behaviourist principles to teach the birds new songs, /.../ individuals could be taught to take different harmonic roles. The process could take months, but in the end a polyphonic dawn chorus might be achieved. [34, p. 210].

Clearly, these proposals challenge traditional assumptions about computer use and support development of new possibilities for the design of everyday computational things.

We can also consider the research programs that introduced novel approaches such as ubiquitous computing and tangible media, as they tend to use both artworks and experimental design objects as illustrations. For instance, one of the primary examples of calm technology – the *Dangling String* – is made by an artist, Jeremijenko [86]. Bishop's *Marble Answering Machine* is presented as a source of inspiration in tangible media [46]. Further, experimental design by Dunne and Raby on *Fields and Thresholds* has served as inspiration for work on interfaces that act in the periphery [24, 46]. What is inspiring with these examples is not their practical functionality nor their technology, but how they differ from more traditional human-computer interfaces.

When we turn to everyday life in general, we have to extend our notion of use to encompass aspects such as social and aesthetic qualities as well, and therefore, a strict focus on usability is not sufficient. Given the expected impact of computational technology on everyday life, it might even be the case that usability *per se* is problematic. Dunne argues against a tight psychological fit between people and technology [23], and Meurer presents a related argument:

> By introducing microprocessors at all levels of our everyday lives, we have altered our understanding of use and the way in which we use things. /.../ The social, cultural, and ecological problems unleashed by these developments reveal how necessary it is to rethink our concept of use and ease. The easier something is to use, the less we think about how we are using it and the "side effects" of such use. The more perfectly a product has been designed, the less we are tempted to consider any problems posed by it or its use. [61, pp. 46f].

It is probably not the case that usability is something to be avoided, but we cannot simply assume that technology that is easy to use, or technology that is invisible, is "good" technology (cf. also [7, quote on page 14]).

The development towards ubiquity of computational technology in everyday life urges us to rethink what a computational thing is in respect to how we are going to live with these things. To broaden our understanding of the design space of everyday computational things, we have to revisit basic issues in human-computer interaction. New theoretical frameworks for design for different qualities in use and roles in everyday life, can help us gain new perspectives. We can use experimental and critical design to create examples of what everyday computational things might be, and get a richer basis for discussion and reflection.

3 Thesis

The design space of everyday computational things include both what we normally call "computers", and various everyday artefacts being computerised. Agendas such as ubiquitous computing, augmented reality and tangible user interfaces have provided examples of how desktop computers can be replaced with solutions that are integrated with things and environments in various ways. The transformation of various everyday things by means of embedded computational technology illustrate the powers of computing in things we would not even consider to be "computers". Thus, there is a significant amount of possibilities for using computational technology when designing things for everyday life.

The topic of this thesis is how to design for *living with*, rather than just *using*, computational technology. To design for everyday life involves much more than supporting people to accomplish certain tasks more effectively, and therefore, design for usability and practical functionality is not sufficient. Since the concern here is how to design things, it is, however, not enough to criticise existing approaches to interaction design by pointing out their limitations outside their original domain; for such critique to be meaningful, it has to be accompanied with practical examples of alternative approaches to the given problems. To support discussion of, and reaction upon, how to design everyday computational things, we therefore need new design philosophies and examples of how such philosophies can guide design.

The ambition with this thesis is, therefore, not to answer a specific question regarding human-computer interaction, but to develop a more general design philosophy for how to design computational things for *presence* in everyday life. Such a design philosophy does not have to be a replacement for existing approaches; rather, it should be a critical contribution to the discussion and analysis of information technology development.

To develop such a design philosophy, we have used experimental design to make investigations into the design space of everyday computational things. By creating a collection of design examples of how such things can become integral parts of everyday environments, we can get both knowledge about the design space itself, as well as a basis for discussion and reflection. Our starting points for this investigation have been:

- amplification of everyday things and environments using computational technology
- forms of information presentation
- time as a central design variable
- use of everyday materials in the design of computational things
- the aesthetics of computational things in use

The details of these investigations are reported in the seven papers included in the thesis. They are:[3]

1. Redström, J., Dahlberg, P., Ljungstrand, P. & Holmquist, L. E. (1999). Designing for Local Interaction. In: Nixon, P., Lacey, G. & Dobson, S. (Eds.); *Managing Interactions in Smart Environments*, pp. 227-238. Springer-Verlag.

3. Below, the papers are also referred to as [P1] – [P7].

2. Holmquist, L. E., Redström, J. & Ljungstrand, P. (1999). Token-Based Access to Digital Information. In: Gellersen, H.-W. (Ed.); *Handheld and Ubiquitous Computing*, Lecture Notes in Computer Science No. 1707, pp. 234 - 245. Springer-Verlag.
3. Redström, J., Ljungstrand, P. & Jaksetic, P. (2000). The ChatterBox: Using Text Manipulation in an Entertaining Information Display. In: Fels, S. S. & Poulin, P. (Eds.); *Proceedings of Graphics Interface 2000*, pp. 111-118. Canadian Information Processing Society.
4. Redström, J. Skog, T. & Hallnäs, L. (2000). Informative Art: Using Amplified Artworks as Information Displays. In: Mackay, W. (ed.); *Proceedings of DARE 2000 (Designing Augmented Reality Environments)*, pp. 103-114. ACM Press.
5. Hallnäs, L. & Redström, J. Slow Technology; Designing for Reflection. Accepted for publication in: *Personal and Ubiquitous Computing*. Springer, London, U.K.
6. Hallnäs, L., Jaksetic, P., Ljungstrand, P., Redström, J., & Skog, T. (2001): Expressions; Towards a Design Practice of Slow Technology. Accepted for publication in: *Proceedings of Interact 2001*, IFIP TC.13 Conference on Human-Computer Interaction, July 9-13, Tokyo, Japan.
7. Hallnäs, L. & Redström, J. From Use to Presence: On the Expressions and Aesthetics of Everyday Computational Things. Submitted for publication.

Below, the papers are shortly introduced.

In *Designing for Local Interaction* [P1], limited communication range between devices was used as a basis for design rather than as problem to solve. By focusing on the notion of proximity as a criterion for information relevance, we aimed to investigate questions such as: how users can create a computational environment in an ad-hoc fashion; how aspects of activities such as local mobility can be used as a basis for information filtering: how information technology can support group awareness when travelling together; and similar issues regarding proximity and local interaction.

Token-Based Access to Digital Information [P2] is about how everyday objects can be used as representations for digital information and be incorporated as parts of the interaction. The paper is based on an analysis of a set of tangible user interfaces and experiences from the *WebStickers* project [54]. The focus is on the distinction between *tokens*, *tools*, and *containers* and in what ways they represent and manifest digital information.

The *ChatterBox* [P3] is an experimental information display based on a combination of text analysis, generation and presentation. Its basic function is to collect and analyse texts produced at a given place, e.g., an office, store them and then continuously generate new texts based on the analysed material. Finally, the resulting texts are presented in a public place, such as a corridor. The paper describes the design of the ChatterBox as well as use experiences.

Informative Art [P4] is a design program for exploring new appearances for information displays. Informative art is designed to look like ordinary (but electronic) pictures, posters or paintings. Over time, however, their dynamics are revealed as they are continuously modified according to changes in the information source they represent. The ambition was not to create art *per se*, but just to use the notion of an art object as a starting point for creating prototypes. The paper describes a series of examples that illustrate different relations between the display surface and source(s) of information, such as mapping information to a single colour using the RGB-code as representation, mapping information to the size and placement of objects, and mapping information to the generation of visual structures using generative grammars.

The fifth paper describes a design program called *Slow Technology* [P5]. Slow Technology is an agenda for experimental design of technology made for moments of reflection and mental rest with focus on the aesthetics of things in use rather than their practical functionality.

Expressions [P6] describes examples of how the design program of Slow Technology has been realised. By interpreting acts in everyday life as acts of reading and writing information using information technology, we investigated different expressions of computational things in use with focus on aesthetics.

The seventh and final paper entitled *From Use to Presence* [P7] describes the development of the theoretical framework of Slow Technology. Here, we revisit the question of what a computational thing is and discuss how design for presence with focus on expressions and aesthetics of computational things in use can help us move beyond design for practical functionality and usability.

4 Method

4.1 General Methodological Framework

The theoretical framework of this thesis is the *new informatics* as described by Dahlbom [18]. The new informatics is a design oriented research discipline directed towards information technology *use*. The new informatics is engaged in design work, creating new technology use. The focus on information technology use means that it is not technology *per se* that is the subject matter, but its potential roles in our lives, our organisations, our societies, etc.

On a more general level, the new informatics can be considered an artificial science [18]. Simon remarked that the modern world is an artificial world, i.e., a world of artefacts [77], and proposed a science of the artificial as a theoretical foundation for design. While Simon's framework is concentrated on design as problem-solving by means of rational search in a given space of possibilities, Dahlbom's call for a new science of the artificial is focused on the normative, social and political aspects of technology use and development [19]. Unlike nature, the man-made world is created and it can be changed [17, 19]. The collection of artefacts that surround us represent more or less conscious choices and decisions people have made regarding what technology to develop, how to design it, what goals to pursue, what qualities in use to aim for, etc. Clearly, most of these decisions could have been made differently and in some cases other decisions would have resulted in better technology. When we study artefacts, we therefore do not only face the question of what already is, but more importantly, the question of what could be.

When we introduce something new in everyday life, we also change what was there before. To use Borgmann's example: by introducing the television set we do not only alter our home environment, we also, to some extent, transform the question of what to do in the evening to a question of what TV-show to watch [6, p. 112]. Television introduces a new role for technology in life, but it does so at the expense of other things. In this way, our lifeworlds are formed by the things that we – more or less consciously and willingly – choose to have around and therefore, these choices represent "moral decisions" [6] that we make regarding how we lead our lives. Ideally, we should not make such decisions on behalf of other people. However, since we are developing new forms of technology use, we do make decisions as we choose to create certain things but not others. Still, we can expose these questions in critical design by not hiding the technology behind a smooth and seductive surface, by not making the technology itself invisible, etc., but instead maintain a distance, or friction, between people and technology to encourage reflection and discussion (cf. [23]).

The research process begins with formulating a design program based on a set of initial conjectures about the design space and how to investigate it. The investigation undertaken in this thesis is not about refining and optimising existing artefacts, but rather on the development of a collection of examples that illustrate different possibilities within this design space (cf. [33]). Thus, this is not a well-defined problem that lends itself to a rationalistic search for an optimal solution. Instead, we use experimental design as a way of finding a path into a problem that is poorly understood at the outset. A design program serves as a starting point and a framework for such investigation.

The next step is to formulate more specific design ideas and working hypotheses that can be addressed in practical work, i.e., by working with designing, implementing, testing and evaluating prototypes. In all of these steps, new experiences are gained and new design opportunities are discovered; the implementation of a specific prototype can expose new design opportunities, as can results from a field study of some specific situation or setting. Of central importance is to be attentive to what happens during this process of realising the ideas from the design program, since just working through the steps to arrive at a final solution will not in itself result in the knowledge we are after. The experience gained and the new design opportunities discovered lead to a new set of working hypotheses, usually directed towards a more specific part of the design space, and finally to reformulation of the design program or the development of a new design program. Thus, we have a process of:

i) formulating a design program;

ii) realising the program by designing, implementing and evaluating design examples;

iii) reflection and formulation of results, e.g., reporting on the experiences gained, formulating new working hypotheses, reformulating the design program.

This process is in part similar to methods for iterative prototyping and stepwise refinement in systems development, where one moves from the more abstract towards the more concrete in iterative steps (cf. [5, 21]). An important difference, however, is that the method employed here is not primarily designed to lead to increasingly more advanced or "better" prototypes. Instead, it is the development of the questions asked and the hypotheses posed that are in focus: we move from the more general to the more specific as our understanding of the design space deepens and we are able to formulate new and more detailed hypotheses. Thus, the prototypes themselves are not necessarily more advanced in later steps of this process, which in turn is one reason for referring to them as design examples instead.

Part of the design philosophy developed at the PLAY research group (cf. [42]) – in which this work has been done – is to work with inexpensive technology. While this was originally due to the financial situation of our group, it has also become a statement against the expensiveness and complexity of much information technology. Working with limited technology can also inspire new perspectives and when it comes to developing computational things for everyday life, the cost involved in producing a design is an important aspect in evaluating its feasibility.

Below, the application of this general methodological framework in the thesis work is described in more detail.

4.2 Research Process

Designing for Local Interaction [P1] is based on a series of projects concerning local interaction and communication that were proposed as a part of the *Intelligent Environments* project [40]. Following a first prototype – the *Hummingbird* [43] – which implemented the very basic ideas, and the results obtained from evaluations of it [43, 81], we developed its functionality further in the so-called *Generalised*

Hummingbirds. This slightly more advanced device in turn opened up for new perspectives of what could be done with limited communication range between computational devices, and with additional inspiration from a field study of news journalists made by our colleagues (cf. [28]), the *NewsPilot* system was designed. With the NewsPilot, we were coming close to the scenarios of the original project proposal and so the experiences gained were analysed and reported in the paper included here. More recently, a start-up company called *Wunderkind*[4] was formed around a new device based on ideas and results from these projects. Thus, we have a process of moving from a general project program to commercial products via a number of prototypes, much in line with the research approach described in Holmquist [41].

Token-Based Access to Digital Information [P2] has a similar background in the Intelligent Environments project [40]. Unlike [P1], which was almost exclusively based on our own experiences, [P2] is based on an analysis of a number of tangible user interfaces with focus on how they address association between physical representation and digital information. The *Webstickers* system [54], which uses barcodes, is used to illustrate design opportunities regarding how everyday objects can be used as tokens for digital information. Webstickers was developed using iterative prototyping: an early version was presented in [53] and after evaluation, the system was re-designed and once again evaluated in a user study. This final system was presented in [54].

In many ways, [P1] and [P2] represent the background against which the later projects should be seen: they represent our first endeavours into areas such as ubiquitous computing and tangible interfaces, and they are also rather typical to design oriented human-computer interaction in terms of research approach. The interplay between design phases and evaluations such as user studies of various kinds to support reflection and formulation of results, also fits into frameworks for HCI research such as [58] (cf. also [4]).

4. Cf. www.wunderkind.se

With the ChatterBox [P3], we set out to explore a sub-field of ubiquitous computing and tangible media called ambient media, i.e., new kinds of information displays that are integrated with the physical environment. The notion of designing for the periphery of attention, inspired us to consider different forms of use. However, while most ambient displays explored new forms of information presentation to reduce cognitive load, we were interested in transforming information for other purposes than just to "inform", such as to entertain, inspire or even confuse.

At the beginning of the project, we continued to use a similar combination of design phases and user studies. First, a simple prototype to test the basic ideas was created [70]. Results from preliminary evaluations revealed problems in the initial design, which was based on pure random recombinations of words collected in a database, and so a second, more advanced system was designed and implemented. We performed several studies of this prototype in a range of settings. First, it was installed at two offices during two weeks. At the end of the test , we evaluated the ChatterBox using both fill-in forms and on-site interviews. In addition, the ChatterBox was used at a few reception parties.

During these evaluations it became evident that our basic method for evaluation would not work properly. Originally, we had the idea of creating something that could serve as a source of inspiration and thus it seemed reasonable to ask questions concerning its qualities as such. To do a proper user study, one needs a precise definition of intended use on which to base evaluation criteria. Further, one needs a way to map the results back to the design choices made. "To inspire" or "to entertain" are, however, not very precise notions of use. Given the difficulties with defining even the narrow notion of use in usability studies, and evaluating it properly (cf. [32]), it is not clear what functionality in use we actually evaluated by performing these interviews. Even if we had found out to what extent the ChatterBox had inspired people, it is not clear how these results could be mapped back to the specific design choices made, such as to what analysis, transformation and generation techniques were used. From this point, the question of forms of evaluation and alternatives to traditional user studies to support reflection and formulation of results became an important part of developing our research method.

The primary quality of the ChatterBox is not whether it actually increases creativity at an office, or if it is entertaining to this or that degree. Its values lies in what new ways of thinking about information technology use it can provoke. From the evaluations we learned that we had neglected the importance of the expressions and aesthetics of this kind of technology. Not in the sense that it was not properly "styled" to fill its intended role, but that it should be seen as an experiment with expressions of information technology rather than as an application with some specific functionality. This became especially evident when we later exhibited it together with some pieces of Informative Art at an art museum. At the exhibition, different people "used" it in very different ways: a group of teenagers used it as a kind of message board, others wrote messages to find out how the text transformations worked, still others just watched it, etc. In this case, no explicit descriptions of the ChatterBox intended functionality were given and so its "use" was open for the "users" to decide [5].

The work with Informative Art [P4] represents the first steps towards a new working method based on more explicitly formulating a design program and then creating a number of design examples based on that program to investigate and learn more about the design space in question. Previously, we had concentrated on working with one or two lines of prototypes gaining experience and understanding of the initial problem by improvement and development of these. This strategy is also evident in the work with the ChatterBox. In comparison,

5. The experiences from the art museum exhibition is not reported in the ChatterBox paper (since the exhibition took place after the paper had been published), but the traces of this re-valuation of how to look at it as a design example, can be seen in the series of texts describing it: from the early prototype in [70], in [P3], in [P4] and finally in [P5].

Informative Art is a step towards working with a collection of examples, each representing some aspects of a possible solution to the posed problem.

When working with Informative Art, we began to formulate a more detailed design program for investigating the expressions and aesthetics of information technology. The design program of Slow Technology [P5] was directed towards investigating computational technology as a design material.[6] Here, the method of formulating a design program is more explicit and the design program itself is given more attention in both the design practice and in the papers written.

The first attempts to realise the design program were made for an art museum exhibition held at the Borås Art Museum in May, 2000. The exhibition was a one-day event and took place during the city's yearly "night of culture". The exhibition included the ChatterBox, several examples of Informative Art using both traditional displays and projections on various materials, as well as the *Fan House*, the *Sail House* and *Chest of Drawers* described in [P6]. At the exhibition, we did not attempt to make any "user studies", but the group which had been working together producing the exhibition were all present, talking to visitors, discussing the designs, etc. The many hours of discussions with visitors gave valuable input for further work and helped us focus on what seemed to be critical issues.

One of the things we found out was the importance of what combinations of materials were used. This was first indicated in the early work with the ChatterBox but was accentuated at the exhibition. For instance, there was a great difference between traditional LCD-displays and projections on fabric: to many visitors, even the neutral design of the LCD-displays dominated the overall expression – something which was not the case with projections on fabric. When developing the next generation of design examples (described in [P6]),

6. Later, we found that movements such as "slow food" (cf. www.slowfood.com) and even "slow cities" have been under development for several years (cf. [1]).

we therefore concentrated on using materials traditionally used in interior design, such as fabric, wood, and paper. These examples were mainly built using material found lying around at our homes and at the office, as well as things bought at, e.g., the large Swedish furniture store IKEA. Thus, the design examples in [P6] are literally based on various everyday things and materials.

The examples described in *Expressions; Towards a Design Practice of Slow Technology* [P6] were based on various interpretations of what it might be like to read and write information in everyday life using computational technology. It represents a return to working with the explicit use of computational things but with a different perspective: instead of working with functionality in use, we concentrated on the aesthetics of use. Thus, [P6] is a point of closure where the initial experiments with various objects and materials in Webstickers [54] and [P2] are revisited, as is the idea of creating a computationally amplified environment from [P1]. Still, the perspective on both computational technology as material for design, and its relation to other materials, the rest of the interior, etc. has changed significantly.

From Use to Presence: On the Expressions and Aesthetics of Everyday Computational Things [P7] is a theoretical paper based on the experiences gained during the work originating with the ChatterBox – when we first began to question how we approached "use"– and onwards, but takes a more general look on what it means for a computational thing to be present in everyday life, or in someone's lifeworld. In relation to the design practice, the aim of this paper is twofold: i) to reflect upon and report the more general experiences gained, and ii) to develop a theoretical framework on which future design experiments can rest. This corresponds to the last step in the general method described above.

4.3 Discussion of Method

The new informatics stresses engagement in design [18], and that artefacts are designed rather than documented [17, p. 70]. A basic problem in design research is that there is no settled tradition of what design research is and exactly how it is to be carried out (cf. [72]). Buchanan states that: "No one seems to be sure what design research means. Should design research follow the model of traditional academic disciplines, or should it seek a new model, based on the intimate connection among theory, practice, and production that is the hallmark of design?" [10, quoted in 72]. Central to the difficulties with defining design research is the interplay between theory and practice in working with design problems, and that the design problem is a question of instantiation rather than generalisation;

Research in human-computer interaction frequently uses psychology as its basis. Shneiderman states that "Each experiment has two parents: (1) the practical problems facing designers, and (2) the fundamental theories based on psychological principles of human behavior." [76, p. 32]. By formulating hypotheses that can be addressed by the methods of experimental psychology, data can be gathered, analyzed and finally new design solutions can be recommended. While experimental psychology is suitable for investigating aspects such as usability, it is not necessarily a useful way to uncover new roles, values and places for computational things in everyday life. If we instead consider computational technology a social, cultural and aesthetical phenomenon, psychology is just one out of many possible ways to ground and inspire experiments. Depending on the research questions at hand, we will have to substitute psychology for sociology, cultural studies, aesthetics, philosophy of technology, etc., or some combination of these. This also means that we need a more general framework for the design of computational things.

The notion of a science of the artificial, first proposed by Simon [77], provides a general framework for what design research can be. Simon's account of design research has, however, also received much criticism. Following Rittel, Buchanan argues that design problems constitute a specific kind of problems that are "wicked" in nature [9] and inherently indetermined, i.e., that the conditions for solving the problem are not possible to capture completely, which in turn makes a rationalistic search for a solution impossible. Rittel has argued that wicked problems have no definitive solution, and that no formulation or solution of a wicked problem has a definitive test [Rittel quoted in 9]. Even if design problems are not inherently indeterminate, the complex context of most non-trivial design problems make them near indeterminate in practice.

Instead of trying to reduce the design problem to a matter of logic, several different frameworks describing the nature of design as an interplay between theory and practice have been proposed. Winograd and Flores based their framework for design on phenomenology, mainly (some interpretation of) Heidegger, and describe how practices are interrupted by breakdowns that open up for reflection and discovery of new design opportunities [90]. Other philosophical strategies such as language-games have also been used to describe the nature of design problems and practices (cf. [25]). It has also been suggested that design can be seen as *bricolage* (cf. [17, 55]).

Schön used the notion of "reflection-in-action" to describe the interplay between practice and reflection as a way of developing an understanding of the problem itself and possible solutions that could not be formulated at the start [73, 74]. For instance, Schön uses the term "seeing-as" to describe how designers approach new situations by reflecting upon perceived similarities between previous experience and the new problem at hand. According to Schön, the strategies for dealing with complex problems found in design practices are also evident in scientific investigation:

> /.../ experiment aimed at testing a particular hypothesis or achieving a particular technological effect repeatedly produces unexpected phenomena which trigger new hypotheses, goals, and questions. Experiment functions at the same time to test technological moves, discriminate

> among plausible scientific hypotheses, and explore puzzling phenomena. /.../ the "science" in question is not after the fact presentation of knowledge of the sort usually found in the scientific journals but before the fact, apparently disorderly research of the kind sometimes described as "the art of scientific investigation". [73, p. 177].

The general method used in this thesis is closely related to these views on the nature of design problems, and on the importance of a combination of reflection and action in addressing them. We might say that design problems are developed, rather than solved, within a design practice (cf. [56]). Common to these frameworks, is that they stress the importance of what happens during the design (and research) process: as understanding deepens, breakdowns occur and design opportunities are revealed, new phenomena appear, etc., we continuously discover new possibilities. By reflecting upon the experience gained during the design process, we can proceed and stipulate new working hypotheses, change working method, etc. Attentiveness to what happens during the process, and not just during evaluations, is something that the method used here was devised to support.

The inspiration for working with a design program and example collections came from other areas of design, such as architecture, graphical and industrial design, where designers and artists work with creating a set of examples exploring different properties of a material to develop an understanding of it. An understanding of what can be done with oil painting, wood sculpturing, etc., can perhaps only be achieved by working with the material in question in practice. An investigation of an area or design space by means of building a collection is not restricted to material properties, as can be seen in e.g., [34] where a similar approach is used to uncover new parts of the design space of information appliances, primarily in terms of emotional and social values.

Prototypes are frequently used as demonstrators of feasibility. Prototypes also make various evaluations and user studies possible. In the approach employed here, however, the design examples also become arguments (in material form) in themselves. The design examples are created to support critical reflection upon the design of computational things and thus the design choices represent some interpretation of, and relation to, the questions addressed. Just as working with the design problem is a combination of theory and practice, its "solution" is present in both the theoretical reflections and in the physical artefact itself. In this sense, the design examples are integral parts of the arguments made (cf. [75]).

When we think about design in terms of change and how to change the state of the world of artefacts, it is clear that this is not only a matter of problem-solving but a matter of constructing the world we live in (cf. [19, 61]). Technologies are not neutral; rather, they are intimately interwoven with human practices (cf. [6, 45]). While Simon seemingly aims to reduce the distance between natural and artificial science by introducing a framework that would support a more formalised and objective description and design of artefacts, Dahlbom calls for an artificial science that emphasizes the differences:

> /.../ [taking an artificial science approach] means that rather than stressing such natural science values as careful documentation and reasoning, methodological acumen, knowledge of the field, the quest for abstract, fundamental principles, universal truths, the scientific community will begin to stress problem relevance, human interest, imaginative scenario building, and good ideas. /.../ It means that there will be a growing framework for future archeological explorations of the socio-technical possibility space". [19, p. 13].

In this manifesto, the central ambition becomes how to improve the world of artefacts to better support what we believe to be the good life.

The importance of a critical dimension in design research is in part a consequence of the fact that the artificial is created rather than discovered. Dahlbom argues in favour of an artificial science that is value oriented, normative and engaged rather than neutral, descriptive and detached [17, 19]. Ehn stresses the social and political dimensions of design [25], and that there is a need for critical development of information technology that unite art, science and technology [26]. Buchanan makes the following remark in his discussion of design as rhetoric: "The point, however, is not simply that technology is distinct from science. More important, it is that technology is fundamentally concerned with a form of persuasion and, as with traditional rhetoric, speaks from no special authority about the good life. It provides only resources that are used to support a variety of arguments about practical living, reflecting different ideas and viewpoints on social life. /.../ Design is an art of thought directed to practical action through the persuasiveness of objects and, therefore, design involves the vivid expression of competing ideas about social life." [8, p. 94]. Critical design, therefore, is an important way of exposing issues in technology use and development.

5 A Design Philosophy for Everyday Computational Things

The specific results from this investigation into the design space of everyday computational things are the design examples presented in the individual papers. This collection of examples illustrates a set of parameters, and design opportunities, in this design space. The general results of this investigation are described as a design philosophy for how to design computational things for meaningful presence in everyday life.

The design philosophy is based on a set of premises, or design *leitmotifs*. While these basic premises can be considered general results from the experiments, they are also used to declare a position I take in relation to the questions investigated. Thus, this design philosophy is normative, and its value depends on the extent to which it supports further investigation and development of everyday computational things; its basic premises are not "universal truths" but suggestions for how to approach the design of everyday computational things based on the work reported here. The design philosophy rests on the following four premises:

(1) Computational technology is a design material

(2) Time is the central design variable

(3) Presence precedes use

(4) Aesthetics is the basis for design

The theme of this design philosophy is design for *presence*. To consider computational technology a *design material* means that one does not think about computers as the means for implementing a certain functionality. Instead, one works with it as just another material for design, with certain properties and expressions as such. To consider *time as the central design variable* means that one starts with the temporal structures that arise from computation and how to manifest these in space, and not from how to make three-dimensional objects dynamic using computational processes. That *presence precedes use* means that computational things are considered to primarily have *meaningful presence* in someone's life and only secondarily as having a certain practical functionality. This design philosophy also states that *aesthetics*, and not psychology, sociology, etc., is the basis for design. Below, I discuss how these premises are related to the specific results of this thesis.

Computational Technology is a Design Material

When we no longer start from the practical functionality of computational things, the notion of computational technology as simply the means for implementing such functionality becomes unsatisfactory. Instead, computational technology has to be seen as a design material, with – like any other material used in design – certain properties as such (cf. [57]).

In what sense is computational technology a design material? Form and material are what build the appearance of a thing. The term "computational thing" refers to that such things receive their characteristic appearance by means of computations, by the execution of programs. We can say that computational things depend on computational technology as material for building their appearance.

Computational technology as design material is not simply a matter of computer hardware, but about all the things it takes to make something "computational": it takes programs to be executed, mechanisms for executing the programs, interfaces for controlling the programs and "displays" and other interactive surfaces for manifesting the results. Here, we can distinguish two main form elements: i) the temporal structures that are generated by the execution of programs; and ii) the spatial structures that manifest these temporal structures. Thus, the appearance of a computational thing is a combination of temporal and spatial gestalt.

While we can separate these two elements when we consider what builds the appearance of a computational thing, it does not mean that we can separate the design of what a computational thing looks like from the design of how it behaves. On the contrary, it means that creating a consistent overall appearance is a matter of balancing both temporal and spatial form elements. Designing a computational thing for everyday life is not a matter of replacing the traditional beige exterior with a more colourful shell.

The notion of a combination of spatial and temporal gestalt has a number of implications for how we design and think about computational things. The perhaps most important design implication of this is that, in principle, we are free to use any material, e.g., textiles, wood, paper and other traditional materials, in building the spatial appearance of computational things [P6]. Once we realise this, we can work with many different combinations of materials and see how this affects the overall appearance.

We can now formulate a more general answer to how computational technology as design material is related to other materials in building the appearance of computational things. Computational technology is primarily used for building temporal structures by means of executing programs. Thus, its main form element is time and temporal gestalt. To build a computational thing, this material is combined with other materials that are used to build the interactive surfaces and displays that manifest these temporal structures. In practice, this perspective opens up for the use of almost any material in the design of everyday computational things.

Time is the Central Design Parameter

How to design in time will be one of the central issues in an aesthetics of computational technology. Having temporal structures as central form elements makes computational technology different from most traditional design materials and makes the aesthetics developed within practices based on e.g., design-by-drawing, inappropriate. Instead, we can turn to areas such as music, film and drama for inspiration and knowledge of how to craft, or compose, temporal gestalt (cf. Jones' notion of *intangible design* [49, 62, see also quote on page 165]).

Too often in human-computer interaction, time is a parameter that one simply wants to reduce, e.g., when one continuously tries to reduce the time it takes to perform a certain task. This means that we neglect the temporal form element of computational things and its contribution to their "character" (cf. [48]). If we instead want to focus on time as a central design variable, we can use approaches such as Slow Technology to investigate the aesthetics of computational technology [P5]. By slowing things down, we can expose the temporal form element in both design and use. When designing slow technology, special attention is given to how to form temporal structures. When in use, slow technology will more or less force its "users" to pay attention to temporal gestalts.

Presence Precedes Use

The idea of designing for meaningful presence rests on the notion of everyday things as existentially defined building blocks of someone's lifeworld. At some point, the thing has been allowed to enter this person's life and as this happened, it received a certain place or role and became a meaningful object. For instance, the sofa in my living room is not just any sofa that happens to be placed there – it is a particular sofa that gradually has become something that I take for granted as part of my life. We will not capture these aspects of everyday things by a reference to some general notion of use and instrumental functionality, and in this sense, presence precedes use [P7].

Many computer applications have preference settings, bookmarks, macros, etc. that enable users to customize and adapt them to personal habits (cf. the notion of *end-user programming* [64]). The first two papers of the thesis illustrate how an interface can be even further opened up for the user to define and how arbitrary everyday things can be used in this process. We can compare this with how people furnish their homes and other places with furniture, and other objects. Ideally, they should be able to do the same thing with computational things.

In [P1] we found that also very limited propagation of information can be highly useful as much information has relevance only at a certain location or in the vicinity of a certain person. The limited communication range allowed us to use a decentralised approach that means that the users do not have to think about managing an overhead system or infrastructure. In [P2], we used Webstickers [54] as an example of how physical tokens can be used as bookmarks for webpages. The possibility to use any object by attaching a barcode sticker to it, opens up for the creation of personal milieus of physical representations for digital media. It also illustrates how the properties of tokens can be used to represent properties of the associated digital information.

Another possibility is to work with more implicit forms of use. The experiments with the ChatterBox [P3] and Informative Art [P4] are examples of such an approach. These systems are not designed to be explicitly used in the way tools are, but instead to be parts of a given environment similar to how decorative objects are used to furnish homes, public places, offices, etc. However, they also paved the way for the examples presented in [P6], and how we can design for presence by focusing on the expressions of things instead of their functionality. In [P6], the use of computational things was further elaborated upon using designs based on re-interpretations of various acts in everyday life. Here, acts such as what walking into and out of a room, pushing and pulling drawers, throwing paper in the wastebasket, etc., were interpreted as acts of reading and writing information using computational technology.

Aesthetics is the Basis for Design

It is clear that we can not design everyday computational things with focus only on practical functionality. It is also clear that computational technology cannot only be considered the technical means for implementing a certain functionality. When we think about computational technology as a material for design, we have to ask the same questions about its properties as we ask about any other design material. When a new material becomes available, it soon challenges present ideas about design, aesthetics, manufacturing, etc., as it opens up new possibilities. Consider for instance the role of materials such as steel and reinforced concrete in architecture or chromium-plated steel and plywood in furniture design in the development of the Modernist movement (cf. [69, 92]). While reinforced concrete initially was just another way to realise certain architectural structures, it soon began to influence the (development of) aesthetics of architecture. Correspondingly, we have to consider the aesthetics of computational technology as a material and the aesthetics of computational things in use.

The expressions and aesthetics of computational things are not only important when we want to understand how to craft a new design material – they are also central when we aim to design for meaningful presence, rather than efficient use, of everyday things. If we think about the acts, or processes, of acceptance when a thing enters someone's lifeworld, we find that before, and in-between, we explicitly use things, they are just there: they are *present*, presenting themselves to us in various ways. A thing presents itself through its expressions. As these expressions become central, aesthetics, as a kind of logic of expressions, becomes the basis for design for presence [P7].

When we design tools, the idea, or image, we have of what it is we are designing is based on some specific use. When thinking about how to design a hammer, we think about what it is to drive a nail. If we are going to design for presence with focus on the expressions of computational things, what such "images" can guide our design? To support thinking about the expressions of computational things, we have developed a number of design leitmotifs. One such leitmotif is to think about computational things as "displays", i.e., as things displaying the execution of programs ([P6], [P7]). To think of a given thing as a display, we can then ask questions such as in what ways and in what sense it expresses the execution of a program, what determines what to be displayed, what initiates the programs, etc.[7]

The perspective on computational things as displays can also be used to get a new perspective on existing things, such as various everyday things that have been computerised. Equipped with questions such as the ones above, we can analyse a given computational thing in regards to its expressions as a display. Imagine, for instance, analysing a modern car, with its computer-controlled engine, anti-lock brakes, anti-spin systems and automatic gearbox, in terms of being a display and not a car. This leitmotif does not only encourage reflections upon the expressions of computational things, it is also a non-technical account of what a computational thing is that can help us uncover new design opportunities for everyday computational things.

6 Concluding remarks

This thesis reports on the development of a design philosophy for everyday computational things. This design philosophy differs from traditional human-computer interaction design in that it focuses on the presence of computational things, instead of their use; their meaningfulness instead of their practical functionality and usability. It differs in that it regards aesthetics, rather than psychology, as the basis for

7. To consider computational things as "displays" is just one design leitmotif that can help us focus on the expressions of computational things in use. Other leitmotifs will help us expose different issues and in many ways, the notions of *amplified reality* [29] and slow technology have served similar functions in the work presented here.

design. It emphasises that time is a central design parameter and that computational technology is not only the means for implementing a certain functionality, but a design material with certain expressions as such. This design philosophy does not support increased productivity; it is a design philosophy aimed at supporting a more general philosophy of technology by providing a collection of examples to encourage reflection and discussion.

This is not to say that the design philosophies behind the personal computer, design for usability, etc., are wrong. The design philosophy presented here simply has a different purpose, different ambitions. Just as we have a plethora of computational things, we have to have a variety of ways of approaching their design. Problems occur when we consider a single design approach to have universal legitimity – everyday life is not a homogenous fabric. As most design philosophies are formed in relation to problems with previous approaches, we also have to remember that their life-spans are limited. Only by continuously questioning, evaluating, reformulating and inventing approaches to the design of computational things, we will have a chance not only to keep up with the pace of technological development, but to actually shape it.

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DESIGNING FOR LOCAL INTERACTION

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Abstract

Much development of information technology has been about reducing the importance of distances and user location. Still, many important activities and events are of local nature, for instance serendipitous face-to-face communication. In order to support such communication, as well as other examples of local interaction, we have developed three prototypes all based on wireless short-range communication. The prototypes are functionally self-contained mobile devices that do not rely on any further infrastructure, making the system inexpensive, flexible and easy for users to manipulate. In these experiments, the limited communication range is not conceived as a problem, but rather as a property that can be explored. We present and discuss the Hummingbirds, Generalised Hummingbirds and the NewsPilot, as well as the implications of this approach for human-computer interaction design

1 Introduction

Information is generally not propagated very far from its origin. Signs can not be read if they are not within sight, signals can not be heard unless within hearing distance, and so forth. In this way, the limitations of our perceptual systems in combination with certain properties of information propagation in physical space (i.e. different kinds of carrier waves travelling through obstacles like walls, floors and outdoor topology) can be said to act as information filters. In order to take part of different sources of information, we have to move around in the environment and in order to talk to each other we have to be co-located.

These limitations are shortcomings of physical spaces that we have been trying to eliminate by the use of information technology. The telegraph made it possible to send messages over long distances, the telephone enabled persons at different locations to speak with each other, and more recently the computing industry introduced us to global networks that make it possible to instantly communicate and share information with people all over the world. The introduction of mobile devices that are carried by their users at almost all times, e.g., pagers and cellular phones, have decreased the importance of location even further.

Still, at times proximity is a rather good measure of relevance. We tend to place important objects near us or near the place we are going to use them. Documents and books lying on someone's desktop are more likely to be related to current work than documents placed in filing cabinets or bookshelves. Considering almost ubiquitous resources (at least in office environments) such as power outlets, water taps or rest rooms, proximity is often the main criteria for relevance. We also move around in our environment in order to get a chance to talk people etc. [3, 4, 30].

The usefulness of location as a constraint for information distribution is perhaps best seen when it is removed: now when we can contact almost anybody any time and instantly access information everywhere we are beginning to experience information overload [21] and communication overflow [19]. Given the apparent importance of local interaction, such as face-to-face communication, and local mobility or "roaming" in search for people and resources, rather little has been done to support it [cf. 3, 4, 30].

In this paper, we describe our explorations of the usefulness of proximity as a constraint for information distribution, starting with development of support for awareness of co-located people. We will begin with presenting related work and then report from three projects all aimed towards supporting local interaction. We conclude with a discussion of our experiences and outline their implications as well as future work.

2 Background

2.1 Local Interaction

Although informal communication *per se* is not our main interest here, research on this topic presents a number of relevant themes. In occurring definitions of informal communication, it is clear that local interaction plays an important part. For instance Whittaker *et al.* [30] uses a wide definition as "taking place synchronously in face-to-face settings"; Fish *et al.* [11] mean that while meetings are pre-planned with a predefined agenda, informal communication is a social event, work related or not, that takes place ad hoc when there is an opportunity for communication. The importance of being co-located has been reported in several cases. Relevant studies include Bergqvist *et al.* [4] who studied ad hoc mobile meetings in a work place; Covi *et* *al.* [7] who studied the effects of dedicated project rooms; Fitzpatrick *et al.* [14] who discussed the difficulties in designing co-operative buildings with support for awareness and serendipitous interaction for distributed groups and Whittaker *et al.* who argued that physical proximity is crucial for informal communication [30].

Extensive research has been done on how to support informal communication using IT. However, in most cases the aim has been to support distributed rather than co-located groups [cf. 9, 12, 14, 20]. The rationale for this is that many incitements for occasional communication are lost when people are not co-located. Thus, support for awareness about peoples whereabouts that could compensate for not having corridors, lunchrooms etc. as sources of such information have been developed. The notion of proximity has also been used as a metaphor in virtual environments designed for social interaction, for instance in Chat Circles [26] and FreeWalk [20]. One of the main differences between these projects and the work presented here is that in a face-to-face setting, the technology does not *mediate* the communication. Therefore, our focus has been on how to *support* communication, for instance by means of providing relevant information.

Another aspect of informal communication is that it is often serendipitous. Hence, technology should support on-the-fly communication, without any need for time-consuming and complex actions on behalf of the user. There are several related attempts to support awareness of colleagues in an office environment [cf. 25, 28]. These systems differ in that they rely on a fixed infrastructure at a number of specific locations, meaning that they only support spontaneous meetings at certain places. Our aim was to support such communication regardless of any specific locations.

2.2 Ad Hoc Networks and Context-Aware Computing

Ad hoc networks are self-organising wireless networks composed of mobile nodes that do not require a stationary infrastructure. They are designed to be rapidly deployed to provide robust communication in a variety of environments, which often lacks a supporting infrastructure [15]. Unlike the work presented in this paper, the objective is to allow for communication between all devices, regardless of the present location. Current research on ad hoc networks is highly technical, mostly about network protocols, rather than taking social considerations or novel applications into account.

Besides communicating, the devices have to make use of what information they send and receive in order to support local interaction. The term "context-aware computing" was introduced as a part of the ParcTab ubiquitous computing experiment [28] to describe mobile and wearable systems that collect data from their environment and use it to adapt their behaviour [1, 24, 28]. A system is said to be context-aware if it keeps track of any aspect of its present context, most commonly location [2, 27, 28]. Thus, being "context-aware" does not imply that the system in question is aware of all aspects of its context.

The prototypes described in this paper are not aware of their absolute position, but only how they are positioned in relation to other devices. A similar approach has been used in a number of cases, perhaps most notably in the LoveGety [18], a recent commercial success in Japan. The LoveGety is a small, wirelessly communicating device that detects other LoveGetys within a certain range, in order to support social encounters between people. Other examples of related systems include the Thinking Tags [6] and GroupWear [5], which tell about relationships between people engaging in face-to-face conversations.

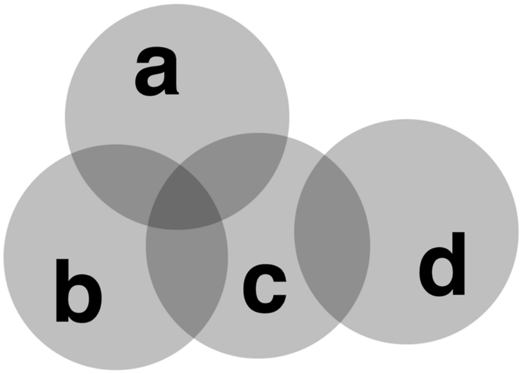

Figure 1: Figure illustrating four devices,
their relative position to each other and what information is available to each of them. The circles represent their respective communication range. In this case, A and B both have access to information distributed by A, B and C; C has access to A, B and D; D has access to C.

3 Experiments

Beginning to explore the possibilities in designing for local interaction, the field of informal face-to-face communication seemed to be an interesting domain due to its dependence on local interaction and serendipitous communication. We have developed a number of applications all using short-range radio-transceivers (Fig. 1). Below, we will describe the Hummingbirds, the Generalised Hummingbirds and the NewsPilot.

The range of the communication varied from about 100 meters in the case of the Hummingbirds, to approximately 10 meters in the NewsPilot, and was deliberately chosen to suit each application.

3.1 Hummingbirds

The Hummingbird [17] is a small wearable device equipped with a short-range radio transceiver, through which it broadcasts its identity and receive information about other Hummingbirds in the vicinity. The devices are functionally self-contained, i.e. non-dependent of surrounding infrastructure. The overall objective is to support awareness of "who's around" within an established group of people. Whenever two or more Hummingbirds are close enough to communicate, the devices give a subtle audio signal and display the identity of the other devices in the proximity. In this way, it is possible for users to know which other Hummingbird users are in the proximity.

Inspired by what is often within "shouting distance", the communication range is set to approximately 100 meters (depending on the number and nature of obstacles like people, walls etc.). The rationale for this range is that as the Hummingbirds do not show in what direction other users are located, the space in which to search for them must not be too large if information about their presence should be

Figure 2: Picture showing the Generalised Hummingbirds,
i.e., GameBoys fitted with radio transceivers.

useful. The reason for not presenting directional cues on the Hummingbird is partly due to technical difficulties, but more importantly the wish to make the devices as unobtrusive as possible, regarding their use as well as the perception of them. It is important that the Hummingbirds are not perceived as surveillance devices.

In studies of user experiences we have found that the Hummingbird is particularly useful in situations where a group of users are outside their normal environment, e.g., when travelling [17, 29]. The Hummingbird experiment has shown that for mobile users, it can be valuable just to have the knowledge that other users are in the vicinity, although it is not possible to use the Hummingbirds to mediate communication.

3.2 Generalised Hummingbirds

The results from the experiments with the Hummingbirds inspired a more general platform. The hardware is based on the Nintendo GameBoy, a hand-held video game. The GameBoys are fitted with small radio transceivers that are connected to the devices' serial ports (Fig. 2). The range of communication is about 50 meters. The reason for decreasing the range compared to the original Hummingbirds, is the fact that more sources of information would be used and that information therefore had to be filtered to a greater extent. Modified game cartridges are used for installing custom software.

The Generalised Hummingbird enables users to give their devices arbitrary names, making identification easy. As with the original Hummingbird, Generalised Hummingbirds are only able to communicate by means of sending and receiving their digital signatures (i.e. their "names"). In order to support events over a wider time frame than the present, the names received are displayed as being in one of two states: "active" when the Generalised Hummingbird is currently picking up the signature in question, and "inactive" when the device recently has picked up the signature but ceased to do so (within the last half an hour or so). This enables users to see a trace of what has happened recently.

Applications

The Generalised Hummingbird enables users to obtain further awareness about activities in their near surroundings using both the "trace" functionality and the possibility to associate devices not only to people, but to places and artefacts as well. For instance, when a user enters a building, an ordinary Hummingbird will pick up what other devices are present, but not which have been there recently. However, if a user places a stationary Generalised Hummingbird at a certain location in the building, its display will show what signatures it has received recently, thus showing a trace of recent activities at that location.

Certain places, like the corridors, act as informal meeting places [cf. 3, 30]. In order to make information about activities in the lunch room available, users can connect a Generalised Hummingbird to a movement detector, ensuring that whenever there is any activity in that room the device is turned on and, thereby, broadcasting its signature. Correspondingly, the activity of some artefacts might be of interest. For instance, it is possible for users to monitor the availability of fresh coffee using a Generalised Hummingbird connected to a coffee machine, so that whenever fresh coffee is available, a device named "Coffee" becomes active.

This experiment illustrates that it is possible to add a variety of information sources to the network using both mobile and stationary devices, without making the human-computer interaction any more complex than in the original Hummingbird example. Adding new information sources is not any more difficult than moving them into the place in question, and if the devices are to be used for keeping track of some activity, ordinary, affordable and easy-to-manage solutions can be used.

3.3 The NewsPilot

The next step of development is the NewsPilot [8], a design based on implications from an empirical study at a Swedish radio station working with broadcast news, conducted by the MobiNews project at the Viktoria Institute. The NewsPilot is based on the 3Com Palm III PDA (Personal Digital Assistant) fitted with a radio transceiver (Fig. 3). The communication range is decreased even further compared to previous experiments, to about 10 meters, since that was a more appropriate range for how far away proximity was relevant at the radio station.

People

The journalists at the station relied on a large number of information resources to select and compile news stories, e.g. local newspapers, television, fellow journalists, etc. The discussions among the colleagues were an important part of the local news dissemination. Often, several journalists had been involved in various related topics, making for fruitful discussions. To help initiating such discussions each NewsPilot user is able to enter a short message stating what he or she is currently working on. By sending out the message together with name of the user, users can obtain information not only about which colleagues are in the proximity, but also what they are working on.

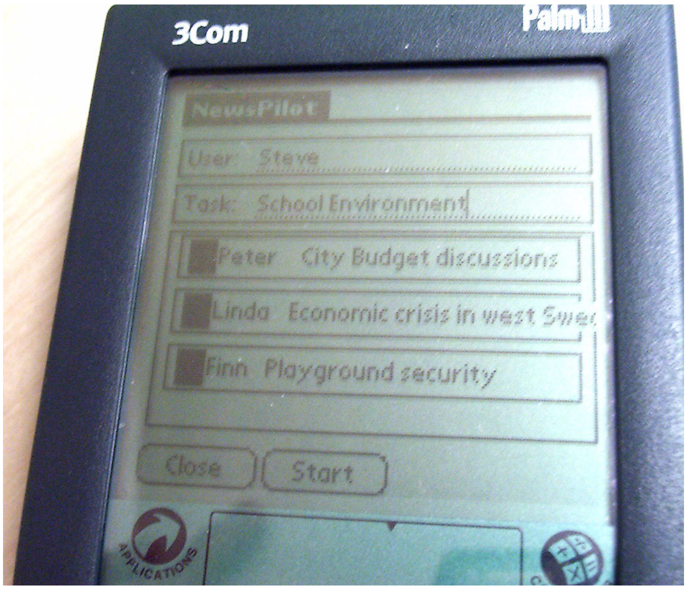

Figure 3: Picture showing the NewsPilot (main screen),
i.e., a 3COM Palm III fitted with a radio transceiver similar to the ones used with the Generlised Hummingbirds (Fig. 2)

Places

The second important finding during the study was that it seemed like different types of information were important at different locations. For instance, there was a table and a shelf with newspapers in the centre of the office used for reading and annotating recent newspapers. When a journalist attended this location, he or she was generally interested in getting information about related stories produced both internally and externally. By fitting transceivers to the walls, messages can be distributed to NewsPilots at specific locations. At the newspaper-table, the task-message from the NewsPilot is received by a wall-mounted transceiver connected to a stationary PC, which is used to search local network resources for relevant information. An additional server is used as an interface between the transceivers and network resources. Short messages about findings are sent back to the NewsPilot and presented to the user. Each message contains an abstract and information on where the full story can be retrieved. Although a user hardly wants to walk to a specific location just to filter out information, if viewed as a complement to traditional searching and browsing, location-based filtering might assist the user in her work.

4 Discussion

4.1 Supporting Serendipitous Communication in Face-to-Face Settings

There seems to be at least two reasons for initiating occasional communication: either (1) that at least one of the participants has a question or subject that she or he wants to discuss, or (2) that the situation as such is an incitement for a conversation. In the first case the subject of the conversation is "known" before the conversation takes place; in the second the subject will be chosen according to the situation more or less spontaneously. While these two cases are superficially similar, the underlying properties differ and will have to be acknowledged in the design of a supporting system.

The first situation is in many respects similar to more "explicit" communication such as phone calls or e-mail, as there are a rather well defined subject and a target person. The main difference is that the property of talking face-to-face is so valuable, that other variables, e.g., when or where to talk, can be left open. A person might choose slightly different strategies in order to catch a talk with her target. Staying in her room will probably mean fewer encounters with other people including the target, than walking around in the office more or less searching for the target. There seems to be a continuous scale of more or less explicit actions in order to make the meeting happen. The key factor for initiating such a conversation is presumably knowledge that the target person is in the vicinity and available for a chat. This is probably one reason why awareness about other people's whereabouts seems important. However, if the proposed discussion target is not available for the time being, there is always a risk that the idea sinks into oblivion. We all need a reminder from time to time, and this is one reason why calendars and to-do lists (electronic or paper-based) are so popular. A future implementation of a support for this first kind of situation might therefore be a context sensitive "to-do-list" that reminds its users when the appropriate context for completing the task turns up [cf. 23].

While the first situation bears on one of the participants having an interest in talking about something, the second one seems to arise out of the interest in talking as such. This might be due to being in a place where social interactions commonly take place, or because the situation as such is suited, or demands for that matter, that people initiate conversations. Consider for instance the following common scenario: a person A walks down the corridor and meets another person B. As they begin to talk A notices that B carries a certain book that she is reading too. As a result they begin to discuss the book, and both A and B might get useful information about aspects not thought of, related references etc. Unless B had carried that book, the discussion might never have taken place. This useful sharing of experiences among co-workers obviously does not rely on one of the participants already knowing what to talk about, but on the situation as such in combination with certain resources present. Thus, a support for this kind of situations will not be in the form of a reminder service, but rather some way of presenting relevant information based on criteria such as the participants present tasks, interests, projects etc. Selection of such information could for instance be a matching between current interests of the users in order to find out the least common denominator and present relevant information, functioning in a way similar to carrying around books in the example above. The NewsPilot was an attempt to provide such a tool for journalists at a news agency.

As we have shown, systems based on locally communicating devices can be used in both cases. The Hummingbird supports an awareness of who is in the proximity assisting a person that has a predetermined wish to communicate. However, it does not provide any help for picking a topic once the parties have met. The Generalised Hummingbird and the NewsPilot provides similar awareness, but with different ranges. Further, the NewsPilot can support persons in choosing a topic to talk about by providing information on what topics other participants are working on. Most of this can be, and have to some extent been, realised using other techniques than local communication between functionally self-contained devices. However, there are some advantages with the strategy employed here that are interesting from a human-computer interaction point of view, some of which will be discussed below.

4.2 Implications for Human-Computer Interaction Design

Let us first sum up a few of the properties of local interaction between devices that we have tried to exploit in order to design easy-to-use technology. The radio transceivers enabled us to use the limited range of communication to create something similar to an adaptive location-based information filter. The communication between the devices was established on the fly, and did not require any explicit actions on behalf of the users. Since the devices are functionally self-contained, users did not have install, configure and maintain any additional infrastructure, except for the stationary information servers used in the NewsPilot, making the systems as a whole easy to manage, move and manipulate.

Our experiences suggest that the principle of *proximity as a constraint for information distribution* can have a wider applicability than what has been presented here. In the Generalised Hummingbirds, we introduced sources such as places and artefacts, and in the NewsPilot users could have information sent to their PDAs when visiting a certain place. The usefulness of these additions suggests that it is interesting to support local interaction not only among people, but with other "resources" in the vicinity as well. For instance, we can use local communication between devices in order to let the user combine their respective functionality in the manner Norman suggested "information appliances" to behave [22]. We can also imagine a scenario where users can create computationally augmented, or rather "amplified" [10], environments using "building blocks" that keep their functionality when moved to new locations: if two units work in a certain way together, they will continue to do so when moved somewhere else.

This stands in contrast to most implementations of ubiquitous computing, in which the rather simple devices users interact with, rely on an advanced "hidden" infrastructure. As the behaviour and functionality of their devices will change radically depending on what hidden resources or infrastructures are there to back them up, users

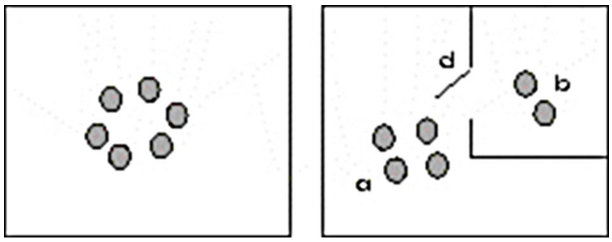

Figure 4: These figures illustrates the problem of proximity
in terms of two different scenarios where different verbal communication ranges apply. In the figure to the left, the relevant cell encompass all six people; in the right one there are two independent groups (a and b). Further, the degree of independency between the two groups of people partly depends on whether the door (d) is shut or open.

will have to care about something that originally was designed to be invisible. This is not very fortunate, considering the aim to hide complexity away from the user. The absence of such hidden resources might help users to build, manipulate and understand their computational environments. Of course, such strictly local networks of devices will not be able to solve all the problems dealt with in ubiquitous computing and intelligent environments, but they might serve as an interesting complement.

4.3 Spaces and Places

When discussing wirelessly communicating devices, the notion of range is often used to describe the size of a cell, i.e. a certain area with a set of devices (people) that all can directly communicate with each other. The term "range" refers to physical distance in space, and it is natural to use this term when discussing spaces. However, the spaces we move about in are, when a social context is applied, perhaps better be understood in terms of *places* [16] or *locales* [13]. A place is the understood reality, e.g. a room, an office or a building, while space only contains spatial measures [16]. Since we are no longer strictly talking about spaces, but rather about perceived places, i.e. a combination of a physical location and a social context, the notion of range becomes somewhat inappropriate.

Consider for instance a group of people sharing a room, where all participants can talk to and hear each other. This can be seen as a communication cell. Suppose we break the group into two smaller groups. Now we have two smaller cells, independent of each other. This makes very much sense when we only use verbal communication, but current wireless communication devices would not follow these changes as the size of the relevant communication range changes depending on context. This is even more obvious in the case of dividing spaces into different rooms (Fig. 4). Developing technology that communicates within a given place (or part of a place, if that is more appropriate) instead of communicating within a certain space would add new possibilities to this kind of technological support. In other words, we want a notion of "proximity" that is more complex and incorporates more than just the physical distance between things, for instance in what social context they are located. To complicate things, different applications might want to use proximity differently. Sometimes the actual physical (spatial) proximity is preferred, as in the case with the Hummingbirds, while other situations might require more adaptive techniques. Clearly, much remains to be done in this area.

5 Conclusion and Future Work

We have tried to make the case that limited communication range is an interesting constraint when designing support for local interaction. We have also discussed some implications of the experiences we have had with our prototypes and discussed the ideas that have arisen during this work. As we have tried to argue, there are a number of interesting properties associated with local interaction between devices, for instance aspects such as information filtering and the possibilities of transparent human-computer interaction.

We have mentioned future projects such as dynamic and context-sensitive to-do-lists and supporting people engaging in spontaneous meetings with relevant information that could enhance applications similar to the ones described here. In order to investigate such applications, the design efforts, combined with user studies and evaluations, will continue. Important issues for future projects do not only include exploring new services for local interaction, but also to develop a "smarter" notion of proximity in order to acknowledge properties of space that are of social importance. Some easily perceived cues, like open and closed doors, windows and walls, are within reach. Designs for more subtle properties, such as different groups talking to each other within a certain room, will be harder to achieve. However, having a technology that could cope with such aspects of the context would enhance its usability dramatically, given the purposes proposed in this paper.

The suggested approach will also have to be evaluated on other domains than face-to-face communication. For instance, the easy-to-manage (from certain points of view, that is) nature of systems composed of communicating and functionally self-contained devices can make it easy for users to create and manipulate their own "smart" environments using a variety of devices. Other important issues in future work include security and privacy issues. So far, the need for authentication or a high security level has been rather small due to the nature of the information distributed. However, when developing other applications those issues must be dealt with.

We believe that support for local interaction is an exciting area. Further development in the areas of wireless networks and mobile computing will make many new types of devices that support local interaction possible.

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TOKEN-BASED ACCESS TO DIGITAL INFORMATION

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Abstract

Several systems have been designed where a physical object is used to access digital information that is stored outside the object, but as yet no common vocabulary exists to describe such systems. We introduce a schema with three types of physical objects that can be linked to digital information: *Containers* are generic objects used to move information between different devices or platforms; *tokens* are used to access stored information, the nature of which is physically reflected in the token in some way; and *tools* are used to manipulate digital information. This paper gives special notice to token-based access system, and design implications for such systems are discussed. As an example of token-based access we have implemented *WebStickers*, where physical objects can be coupled with WWW pages. We present some examples of how tokens are used to access digital information in this system, and discuss future work in this area.

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1 Introduction

In recent years, one of the most compelling visions of the future of computers has been that of *ubiquitous computing*, where computers would leave the desktop and move into the world that surrounds us [14]. By shifting the emphasis from the universal functionality of desktop workstations to small, dedicated computational tools, proposed ubiquitous computing environments hope to make computers as readily available and easy to use as notepads and whiteboards. In some ways, this vision is starting to make its way to reality, and with the continued miniaturisation and decreasing prices of PDAs and embedded processors, much of the technology required to make these visions a reality now exists.

However, with the increased power and complexity of portable computers, there is also the risk of simply replacing one problem with another. By moving all computing functions from one platform to another, perhaps we will not always gain as much as we would hope. Even worse, advantages taken for granted with stationary computers (large screens, high computational power, access to high-speed networks, etc.) are often missing on mobile devices. There is a risk that rather than simplifying the use of computers, the proliferation of a multitude of computational devices will instead make for higher complexity – thus achieving the opposite of the goal of ubiquitous computing.

An alternative approach to accessing and manipulating digital information is to use physical objects that are not in themselves computers, but nevertheless are used for representing information. Most types of information today exists in digital form, including text, images, music, films, and so on. With a suitable infrastructure, it should be feasible to have access to any book ever written, every piece of music ever recorded, any piece of art ever painted, anytime, anywhere, without the need for a physical carrier. However, this might also lead to serious problems in designing the human interface;

experiences with the World Wide Web have already shown us that designing the interface to a practically limitless information space is extremely difficult.

But humans are inherently good at managing physical space, by ordering and sorting artifacts in their environment. Our senses give us many clues to the properties of physical objects, so that we are able to draw many useful conclusions from the way objects look and feel and how they are arranged in our environment [3]. We might take advantage of some of these capabilities when designing systems for accessing digital information, by using physical representations that are in themselves not carriers of information, but act as pointers to some online data.

In this paper, we will examine several such systems, concentrating on approaches where digital information is distributed using physical objects that represent some digital information or computational function. The process of accessing virtual data through a physical object we will term *token-based access to digital information*. The purpose of this paper is to systematise the properties of such systems, and to put them in relation to systems using other approaches, thus forming the basis for a discussion of how we can use properties in the physical world to help us better interact with distributed digital information.

2 Physical Objects as Representations of Information

There is a long history of the use of physical items to represent information, without the item actually containing the information that it represents (cf. [6, 16]). Souvenirs, photographs and keepsakes aid in the remembrance of places, past events and persons, by acting as a trigger for the user to remember certain information. The pieces used in board-games act as representations of the players through which they can perform their actions (cf. [15]). Gambling tokens used in casinos represents a value that is not inherent in the actual piece of plastic, much like the value of paper money traditionally has been guaranteed by a government's gold reserve. Cards of various kinds (calling cards, debit cards, etc.) are used to access assets – telephone call minutes, money stored in a bank account, etc. – that are not stored in the physical cards themselves.

Similarly, tokens in human-computer interaction will trigger the display of information that is digitally stored outside the token in some way. In the research community, several recent systems use physical objects without any inherent computational properties as representations of digital information in some way or another, but there is as yet a lack of vocabulary for describing and analysing such systems. To facilitate a discussion, we will first introduce three different classes of physical objects that represent digital information or computational functions: *containers*, *tools* and *tokens*.

2.1 Containers, Tools and Tokens

We will call an object a *container*, if it is a generic object that can be associated with any type of digital information. We will call it a *token*, if the digital information associated with the object is reflected in the physical properties of the token in some way, thus making the object more closely tied to the information it represents. Finally, some physical objects are to be considered as *tools*, since they are used to actively manipulate digital information, usually by representing some kind of computational function. Some accounts of related work should help clarifying these distinctions.

Containers

Several systems have been proposed in which digital information can be attached to physical objects, often to simplify the task of moving information between various computers and/or display devices. In the *pick-and-drop* approach [7], a pen was used as a container to physically "pick-and-drop" digital information between computers, analogous to how icons are "dragged-and-dropped" on a single screen. *Informative Things* [1] let ordinary floppy disks act as pointers to on-line information by associating them with a digital ID. A disk could thus be shared between users as usual, but would seem to have "endless" storage, since no information apart from the ID was actually stored on the disk. The authors also discuss some future scenarios where other objects might be used as "Things". *mediaBlocks* were small wooden blocks which let digital information be stored and accessed through a variety of different means [12]; for instance, after first associating a block to a digital whiteboard, the block could be used to transfer the scribbles on the whiteboard to a laser printer for printout. Finally, in the *Passage* system [8] information of various kinds could be moved between different computers by "attaching" it to small physical objects called "passengers".

Although all these systems in some sense could be said to use "tokens" to represent digital information, we prefer to call these objects *containers*. Unlike what we will term tokens, containers are generic, in that the physical properties of a container do not reflect the nature of the digital information it is associated with. Taking mediaBlocks as an example, note that by merely examining the physical form it is impossible to know if a block is associated with say a video clip, a PowerPoint presentation or a whiteboard scribble. This generic quality makes containers potentially very useful for the distribution and manipulation of a variety of digital information, but it also means that containers do not provide any additional cognitive cues for the user as to what their "contents" are. Furthermore, containers are mostly used for short-term distribution and access, making them inherently transient in nature.

Tokens

In our definition, *tokens* are objects that physically resemble the information they represent in some way. Tokens are typically only transient if the token itself is short-lived. In the *metaDESK* map-display system [11], a set of objects were designed to physically resemble different buildings appearing on a digital map. By placing the models on a horizontal display, users could bring up the relevant portion of the map, and the physical form of the objects would serve as a cognitive aid for the user in finding the right part of the map to display. In the *ambientROOM* [4], objects were used to represent various types of information, and by bringing an object to an information display, an "ambient" display of that information could be accessed. For instance, by bringing a toy car close to a speaker, ambient sounds reflecting the activities in a toy project could be heard.

In the electronic tagging system described in [13], an object could be augmented with a digital ID tag allowing it to be linked to some digital information, thus letting the physical objects act as a pointer to the digital information. Some examples included a book that was associated with appropriate electronic information, such as the author's web page or a relevant page at an on-line bookstore, and a watch that was associated with the user's on-line calendar. Similarly, in the *WebStickers* system [5], users could attach barcode stickers to objects, and then associate a barcode to a web page that was somehow relevant to the object. (This system will be described in more detail later.)

Tools

Finally, some physical objects are used as representations of computational functions. We will call such objects *tools*. Some tools act as "handles" to manipulate virtual objects. In the *Bricks* system [2], a physical "brick" was attached to a graphical object on a horizontal display, and could then be used to move and rotate the on-screen object. By employing two bricks, a graphical object could be scaled and distorted. Some tools physically resemble the computational function they represent. In the metaDESK system, a physical representations of a magnifying glass was used to invoke functions similar to those of the *magic lenses* explored in graphical UIs [9]. By manipulating the physical magnifying glass, the user could apply the lens functions to a part of the map, thus seeing an alternative display "through" the lens represented by the magnifying glass. Other physical representations such as a "flashlight" were also used. In the electronic tagging system mentioned above (cf. [13]), a French dictionary was associated with a language translation function, so that a text could be translated simply by bringing the physical representation close to the screen where the text was displayed.

Sometimes the distinction between a tool and a token or a container will blur, since when a physical object is attached to a virtual, direct manipulation of virtual properties using the physical representation might become possible. In the metaDESK, models of buildings (tokens) were also used to scale and rotate a map, analogous to the Bricks system. In mediaBlocks, several mediaBlocks (containers) could be used in conjunctions with a workbench to sequence a presentation; the completed presentation could then be associated with a new block. Such "hybrid" systems, where a physical representation has several possible uses depending on the context, are an area where we expect to see much development, but we will consider them outside the scope of this paper.

2.2 A Note on Vocabulary

The definition of *token* in the online edition of the Merriam-Webster Collegiate Dictionary includes:

> **1** : an outward sign or expression <his tears were tokens of his grief>

2 a : SYMBOL, EMBLEM <a white flag is a token of surrender> b : an instance of a linguistic expression

3 : a distinguishing feature : CHARACTERISTIC

4 a : SOUVENIR, KEEPSAKE b : a small part representing the whole : INDICATION <this is only a token of what we hope to accomplish> c : something given or shown as a guarantee (as of authority, right, or identity)

(Note: meanings 5 – resembling money – and 6 – tokenism – have been excluded)

Our intention with this choice of word is to show that a token is a "small part representing the whole", in that properties of the digital information are reflected in the token, and that the token should have some characteristic of the information it is linked to. We considered using some other term, in particular the word *phicon*, which has been used for physical counterparts to GUI icons, but decided against it. In the literature, the term phicon has been used both for what we define as tokens (e.g. the models of buildings in the metaDESK [11]) and for containers (e.g. mediaBlocks [12]), creating some confusion, which we sought to avoid with this choice of terms.

3 Token-Based Access to Digital Information

As we have seen, there are several different approaches to how we can let a physical object represent some kind of digital data or computational function. We will in the following concentrate on what we term *token-based access to digital information*, because this is an area that provides many design opportunities that should be further explored. We will define token-based access to digital information as:

A system where a physical object (token) is used to access some digital information that is stored outside the object, and where the physical representation in some way reflects the nature of the digital information it is associated with

A token is a representation of some digital information, but only by association and resemblance – a token is not a computer or a display. Instead, the user will have to bring the token to some kind of external device to access the associated information.

3.1 Components

In a token-based interaction system, users will need to have access to two types of components:

- A *set of physical objects which are used as representation of some digital information*. These objects we will call tokens
- A *set of access points for the digital information associated with tokens*. These access points we will call i*nformation faucets*, or faucets for short

We have chosen the term *faucet* rather than a term such as *display,* since it can be any type of device capable of presenting information, not just a graphical computer display – perhaps a speaker, a tactile device, etc. Importantly, while a token is by definition not a computer (it typically contains no computational power), neither should a faucet be considered as a computer from the user's point of view. Instead, tokens and faucets together comprise a system that provides users access to digital information – the fact that computer technology, networks, etc., might feature heavily in the implementation of such a system should not need to be of concern to the user.

3.2 Interaction in token-based access systems

Interacting with tokens can be either to access the information associated with a certain token, or to create or modify such associations. These two aspects of the human-computer interaction we will call *access* and *association* respectively.

Access

Fundamental for any token-based system is that it allows a user to access a certain piece of information by means of presenting a token to an information faucet. By controlling the availability of tokens it is possible to control the access to information. For instance, if we allow for a number of copies of the same token to be made, several people will be able to access the information, perhaps simultaneously. Conversely, if we want to restrict access, we might only allow one instance of a token to be produced, and through some measures make it impossible to copy, thus letting the token act as the single "key" to the information in question.

We might also want to introduce some additional constraints on information access. For instance, a *combination* of tokens might be used to access the information associated with all the tokens simultaneously. A more interesting option is to use the combinations as such to form criteria for information access. For example, if two tokens represent work in a joint project, certain aspects of that work might only be accessible when both tokens are presented simultaneously, much like we might require more than one key to open a door.

Depending on the present purpose, information access might be constrained by physical *location* as well. For example, some information might only be applicable at a given location (e.g. a building) and by using tokens that only work with local faucets any distribution beyond that location can be limited. Correspondingly, public information that is meant to be widely distributed will have to use tokens that do not pose such a limitation, but instead are applicable to variety of faucets.

Association

If the association of digital information with a physical token is unconstrained and at any time allows the user to re-associate the token with any other piece of information, we are close to the properties of containers. However, when using tokens it is more interesting to investigate different ways of constraining the set of possible associations. For example, we might want to restrict the associations of a certain kind of tokens to a certain kind of information, thus avoiding some confusions between the how the properties of the token are reflected in the information it represents. We might also make the associations fixed once and for all, making the connection between the token and a certain piece of information as static as possible. This would typically be the case in a public display system, say an interactive museum exhibit, where one would not want the users to be able to change the way information is associated with the physical objects on display.

Further, we might allow a user to associate more than one piece of information to a certain token. This we may call *overloading*. Overloading a token with information might have various effects. For instance, the token might represent different pieces of information at different locations or in different contexts, as is often the case with everyday objects. Alternatively, the user might be able to access several different pieces of information at the same time when applying the token to a faucet. In the latter case, the information might be displayed with a choice of which information to present.

4 A Sample System for Token-Based Access: WebStickers

As an example of token-based interaction, we have developed the WebStickers system [5]. This system is quite flexible, in that it uses the Internet for distribution of data, and thus we can use any computer with the appropriate (off-the-shelf) hardware as a faucet. The system allows users to couple identifiers in the form of barcodes to locations on the World Wide Web. Users are given a set of stickers with pre-printed unique barcodes, and can then attach the stickers to any object they want to use as bookmark. Users then use a barcode scanner to associate a barcode with one or more web pages, and are able to return to a page by again scanning the corresponding barcode. The idea is to allow users to take advantage of the properties of any object in their surroundings and use these properties as cognitive cues to the finding a certain web location.

The system is implemented as a database accessible via HTTP. In the database, identifiers in the form of unique character strings are coupled with URLs. An off-the-shelf barcode reader is used to scan barcode stickers, which are printed on sheets of adhesive stickers using a standard laser printer. A small client application on the user's computer monitors incoming characters from the barcode reader, matching identifiers with URLs by calling the on-line database, and displaying the corresponding web page in the user's browser. To create new associations, the user simply change the mode of the client program from *Goto* to *Learn*, and the currently displayed web page is associated with the scanned barcode in the server database. Using codes coupled with URLs in a database, rather than coding URLs directly into barcodes, makes it possible to create new associations or change old associations easily.

4.1 Modes of Interaction

The WebStickers system provides a basic form of access to web pages through tokens. There is currently no provision for more advanced access forms, such as those provided by combinations of tokens or based on specific locations. As for association, WebStickers currently allows totally free association between web pages and tokens, placing the responsibility of finding the correct token on the user making the association. This is reasonable considering the experimental nature of the current system, but in future versions it might be useful to introduce some restrictions. Introducing ready-made tokens for specific tasks might also be considered. (We already have one such ready-made token in the form of Post-It notes – see below.) WebStickers does allow for a form of overloading, by letting the user associate more than one web page with a single token. When such a token is accessed, the user is presented with an intermediate web page where she can choose from a list of URLs.

4.2 Types of Tokens

With WebStickers, we have been able to experiment with a variety of different tokens as representations of web-based information. Here are some examples.

Transient Tokens

For web page bookmarks that are only meant to be kept for a short time, say no more than a few weeks, we have been using books of Post-It notes with pre-printed barcodes. After associating a note with a web page users can then scribble a comment on the note that helps them remember what web page the note refers to, and attach it to their screen, their notice board, someone else's door, etc. Post-Its are explicitly designed for short-term information, making them ideal tokens to represent transient web bookmarks. After a while the glue in the note will cease functioning and the note will fall off whatever surface it is attached to, at which time the user can select to transfer the bookmark to a more permanent location, or discard it completely.

Tokens with a Direct Digital Analogy

Some WWW bookmarks have a direct counterpart in the real world. For instance, when referring to the proceedings from a conference, it is often more comfortable to use the physical book than to read from an on-line proceedings page. However, when a paper is to be e-mailed to someone else, when it is to be searched for specific terms, when we need to quote some sections, etc., having easy access to the electronic version is useful. We have been using the pre-existing barcodes on conference proceedings for coupling them to their on-line counterpart. Since a book of proceedings is an archival object, it will mostly be stored away on a bookshelf. When working with a book, the user will take it down and bring it to her desk, and now through the WebStickers association she can have immediate access to the corresponding on-line documents as well.

Tokens Tied to a Certain Activity

We have experimented with using objects that are tied to a specific activity as bookmarks to related web pages. A Swedish-English dictionary has been associated with the web page of the Encyclopaedia Britannica, the thought being that when users are searching for a word this web page will come in handy if the physical dictionary is not sufficient. Similarly, a user has tied the cup used for drinking the morning coffee to the URL of the morning news (made available on the Internet by the national radio station), thus tying the activity of drinking coffee to listening to news updates.

4.3 Conclusions from the WebStickers System

By constructing a system for token-based access that allows a wide variety of tokens to be associated with a very large information space (the World Wide Web), we have been able gain experience in how virtual properties can be reflected in physical objects. We have found some very obvious correspondences, such as that between Post-It-notes and transient bookmarks, but feel that it would be useful to generalize the discussion of how to design tokens. In the following, some initial design ideas for future token-based systems will be given.

5 Fitting the Token to the Task

Since a token typically will need to have little or no inherent computational resources, many of the constraints posed on the design of ordinary computers will not have much effect. For example, a token will not need any display; it will not need to have a processor or a power supply; it will be much less sensitive to wear and tear, and so on. This leaves us with far more freedom to design and build the tokens according to other criteria.

The most important criterion will be to design the tokens in a way that clearly displays what they represent and what can be done with them, i.e. their *affordances* [3]. Matching the affordances of the token with the task it is designed to be used in, can be done in a number of different ways including the use of different materials, sizes and shapes. Since tokens are not self-contained but tied to information faucets, the interaction can also be designed to take other factors into consideration, such as the physical position or usage context.

Just like when designing graphical interfaces, care must be taken when designing tokens. For instance, often certain shapes or colours convey values or meaning specific to a culture, like the symbol of the cross does in Christian religions. Whether such cultural values should be used or avoided, will depend on the kind of information to represent and who are going to use it in what context. However, token-based interaction systems will be less loaded with predefined meaning if strongly established symbols are avoided. Below we will sketch some of the possibilities for how the properties of digital information can be reflected in the design of token-based interaction.

5.1 Materials

Tokens can be made in a variety of materials depending on what they should represent. Tokens that represent information that is only meant to last for a short while might be made of material that wears out easily. Consider for example the difference in paper quality between books and newspapers, and in the glue used on Post-It notes and postage stamps. Here, the lack of durability of the newspaper and the glue on the Post-It note are not faulty but intended, since they represent information which is only intended to be used for a short time. A book, on the other hand, is intended to be kept for some time, and a stamp should stay stuck on the envelope that it was attached to.

Similarly, tokens made in fragile materials can be used to represent information that should be handled with care. Tokens made in very heavy materials can be used to represent information that is not supposed to be transported very far from its current location. Tokens representing information that is to be used frequently by a certain user might take the form of jewellery or perhaps a belt made in some comfortable material.

5.2 Sizes and Shapes

Tokens can come in many different sizes and shapes depending on the purpose. For example: tokens that are meant to be passed between users should be graspable. Tokens that are private should afford hiding and must thus be small enough to fit into a pocket or perhaps into the palm of a closed hand. Very large tokens will be harder to move without attracting attention and thus suitable to represent information that is of public interest. If we have a large number of tokens that we need to store in the same place we might want to make them easy to stack or pile. They will then have to have a size and shape that afford this, meaning that tokens similar to cards or discs might be more suitable than tokens similar to marbles.

Further, the size and shape of the tokens can help restricting their use to avoid mistakes. Consider puzzles: besides the colour of a piece, its shape determines where in the puzzle the piece can be applied. This is especially obvious in puzzles made for small children where each of the very few pieces fit into a certain slot. In the case of token-based interaction, using shapes that only fit in certain slots can be used to determine which information faucets are applicable. If the information the token represents is of a kind that only can be accessed in certain information faucets, the shape of the token can be made in a way that only will fit into proper kind of faucets.

5.3 Usage Context

Everyday objects are often used within a special context, and when moved out of that context their "meaning" tend to change. As an example, take the many knives used in a kitchen for different purposes, e.g. cutting bread, meat, fish etc. Sometimes they are stored in drawers in the kitchen. Now imagine what happens if we instead store them in another drawer in the apartment, say, where you usually store your socks or underwear. If someone found your kitchen knifes in your bedroom drawer, he or she would definitely react differently compared to if he or she had found them in the kitchen. Thus, the very location of tools and objects can convey meaning. This should be acknowledged when using tokens for interacting with computers, by means of for example how to constrain access to (e.g. *location* and *combinations* of tokens) and associations (*overloading* tokens) with information.

Thus, we have seen how a wide variety of virtual or digital properties can be reflected in the design of the components of a token-based access system. We have in this paper only been able to sketch the outlines of these possibilities, and many practical design experiments and evaluations will be needed before any firm conclusions can be drawn or any solid design specifications can be given.

6 Conclusions and Future Work

We have attempted to show that token-based access to digital information is a valid interaction paradigm that can be used to support access to information in a distributed computing environment. Token-based access systems differ from container-based systems in that they imply a stronger coupling between physical and virtual data, i.e. the properties of a token should reflect the properties of the data it is associated with. This makes it possible to design tokens that provide users with a strong cognitive support for accessing information in distributed systems. It also opens many possibilities for building in aspects of the user interaction into the token itself, rather than having these solely confined to the virtual domain. For instance, by designing tokens with certain physical properties, say tokens that are easy or difficult to share between users, it is possible to have some desired affordances physically reflected in the token.

For future commercial applications, we can see many situations where it would be more convenient to use token-based access than a physical carrier of information. The music business is currently a good example. With forays already being made into distributing music on the Internet using the MP3 format, in the future it might be feasible that rather than buying a music carrier such as a CD or DVD, consumers will purchase a small token representing a recording. By bringing such a token to a suitable player (faucet), the user can then listen to the music associated with the token. Unlike a CD, the token would never run the risk of being scratched, and through encryption of unique IDs on each token, music companies can make sure that their music is protected. Technical realization of such a system is already possible [10].

As we have seen, several systems for token-based access to digital information have already been realized in research labs, and several systems have also been constructed where physical containers and tools are used to distribute and manipulate data. This serves to prove the technical validity of such systems, and technology for tagging and sensing objects is already good enough to construct useful applications. However, neither this paper nor most previous work has been able to more than touch on some of the most important aspects of token-based access.

In particular, matters concerning security, privacy and rights concerning information associated with tokens need to be considered. Can valuable information be safely made available on public networks without the risk for unauthorized access? Should tokens be possible to copy, and what will then happen to the information and associated access rights? Who should have the right to modify materials associated with a token, and who should be allowed to modify the associations themselves? In the experimental applications, the impact of such decisions has been limited, since the systems have been used only to a limited extent and by a limited audience of mainly expert users, but in the future these questions may come to have a serious impact. The validity of token-based access to digital information is probably more dependent on the resolution of such issues than any technological hurdles.

Before general token-based systems break into the mainstream, we will have to take these matters into consideration, and will also have to refine the way such systems are designed, improving their properties from a user perspective. In this paper we have sketched some initial possibilities for tokens-based access to digital information, but much more work needs to be done in this area. This work must be guided by experiences in disciplines such as user-interface design, industrial design and ergonomics, making for a truly cross-disciplinary challenge. We believe that with the correct approach, systems offering token-based access to digital information can prove very useful in the development of future distributed computing environments.

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THE CHATTERBOX

USING TEXT MANIPULATION IN AN ENTERTAINING INFORMATION DISPLAY

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Abstract

The ChatterBox is an attempt to make use of the electronic "buzz" that exists in a modern workplace: the endless stream of emails, web pages, and electronic documents which fills the local ether(-net). The ChatterBox "listens" to this noise, transforms and recombines the texts in various ways, and presents the results in a public place. The goal is to provide a subtle reflection of the local activities and provide inspiration for new, unexpected combinations and thoughts. With the ChatterBox, we have tried to create something in between a traditional application and a piece of art: an entertaining and inspiring resource in the workplace. This poses several interesting questions concerning

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human-computer interaction design, e.g., information and display design. In this paper, we present the ChatterBox, its current implementation and experiences of its use.

Keywords: Art, entertainment, awareness, ambient displays, text transformation, calm technology.

1 Introduction

Within computing science and interaction design, there is a long tradition of using text processing for various purposes, such as creating interfaces based on natural language, and work on how documents can be processed and transformed for better information retrieval (cf. [9, 20]). The ambition of this work has not been to use text processing to develop more efficient information processing and interaction. Instead, we wanted to use text processing to explore technology designed to be more like the works of art, posters and pictures that furnish our homes and offices, than a “traditional” application.

Inspired by the work of writers and artists, we have explored how the texts produced at an office can be transformed in various ways to be used in a public information display aimed to entertain and inspire. Dadaists and Surrealists, such as Tristan Tzara, Brion Gysin and William S. Burroughs [23], used more or less random creation of texts to create works of art. For instance, Tzara created a poem by pulling words out of a hat, and in the 1950's, Gysin cut and rearranged sections of articles in a newspaper at random to create a novel piece. This technique was called “cut-up” and Gysin later even used a computer as an aid in the process. Burroughs used the cut-up technique in several works, e.g., “Naked Lunch”.

Approximately at the same time as Gysin was working with cut-ups, other writers and artists were experimenting with using words and texts as graphical elements in the composition of a work of art [12]. Transformations of texts were employed to various degrees. If the texts still could be considered as meaningful texts, although presented in a visually striking way, they were called "pattern poetry". If the visual aspects of the poem were so emphasized that it was no longer possible to read the text at all, it was called "concrete poetry". More recent contributions in these directions are, for instance, the "Digital Landfill" and the "Shredder" at Potatoland [17] which are both based on the processing of material available on the WWW.

Artists have long been using computers and information technology as media for expression (cf. [11, 21]). Making ideas go the other way, i.e., adopting ideas and concepts from art and design in interaction design, has often taken a bit longer. However, there are examples of such cross-fertilization: Arnowitz et al. employed concepts developed in art to improve interface usability [1]; Kirby et al. used techniques developed in painting to create multi-layered visualisations; and Gaver and Dunne used public electronic displays to enable people to express their opinions and other information [8], to name a few. We believe that, as computers continuously enters new situations of use and interaction designers have to face new constraints, ideas and concepts from the world of art and design will be increasingly important. The ChatterBox is an attempt to explore work in this direction and to expose issues relevant to human computer interaction.

2 The ChatterBox

While waiting for the coffee machine in the lunchroom to finish, you take a quick glance at the ChatterBox display "We believe the SONY PlayStation to be an important part of HCI research". You recognise the structure of the sentence - it looks like something you were

Figure 1: An installation of the ChatterBox in a corridor using projection on several layers of fabric. The first layer is very thin and moves as people passes by.

working on last week - but it has obviously been transformed since what you were writing was not at all about the PlayStation. Nevertheless, it makes you think about the usefulness of game consoles in HCI research. You point out the sentence on the display to a colleague who just entered the room. After a short discussion, you agree that using a number of game consoles might be an interesting alternative to using workstations for a project, since they are much less complex to a novice end-user and more easily moved between different locations.

The scenario above describes what an encounter with the ChatterBox can be like. The ChatterBox generates and presents texts based on written material produced by a group of people working at an office. Texts are created by recombining material, e.g., substituting words and parts of sentences, while trying to keep the resulting text readable and grammatically correct. The ChatterBox is designed to be more similar to a poster, a picture or a potflower, than a traditional application, as we wanted it to be seen as a part of the environment in a sense similar to we use decorative objects to furnish our homes, offices, etc.

The ChatterBox relies on being fed with material that can be used to generate texts. This is primarily done by sending emails to it, e.g., by making it subscribe to mailing-lists such as the mails sent to a group of collaborators or a project. The ChatterBox is designed to reflect long-term activities, such as interests or projects that are represented in the material that users submit to it. By continuously adding new material to the ChatterBox, its presentation will reflect changes in the activities taking place (in as much as these changes are evident in the material submitted to it). The aim is to provide inspiring and entertaining variations of mostly familiar texts that can act as inspiration to think about the material in novel ways, and act as an incitement for occasional communication by serving as an information resource in public places.

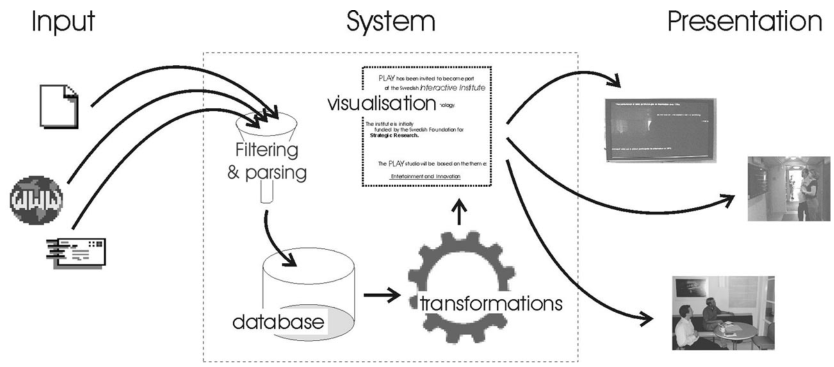


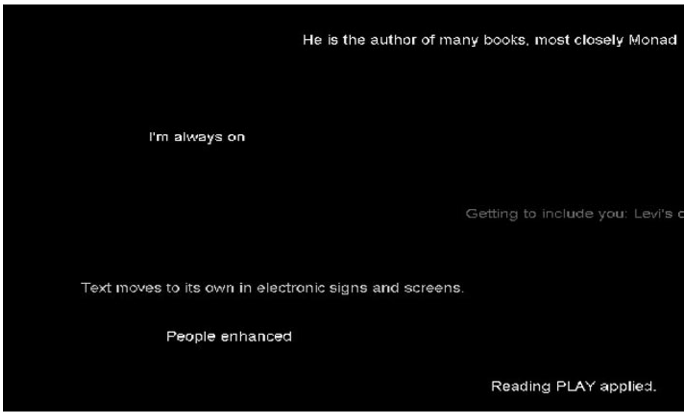
Figure 2: Figure showing the architecture of the ChatterBox system.

The need for users to explicitly interact with the system has been eliminated as much as possible. This is similar to the aim with *calm technology* [25]. However, while calm technology often has been about creating something that remains in the background and only calls for attention when certain events or changes take place, the ChatterBox is continuously changing presenting new material, even though at a relatively slow pace. In order not to disturb users despite being dynamic, its location is crucial. Besides the purpose of making it a public resource, this is the primary reason for locating it in public spaces where people move about and, presumably, not tend to sit and work for longer periods. This stands in contrast to, for instance, the ambientROOM where the goal was to integrate a number of ambient displays in a personal office [14].

2.1 System

An early prototype of the ChatterBox was presented in [18]. This prototype generated random "phrases" consisting of 3-5 random non-frequent words occurring in a collection of texts. Experiments indicated that while the generated "phrases" certainly were novel combinations of words, they were rather difficult to make any sense of. Therefore, a second prototype that makes use of more advanced text-processing saving more of the original context of material (thus keeping more of the original semantics), was developed.

The current implementation of the ChatterBox accepts text based input, such as documents, emails and www pages, from users via a dedicated email account. The architecture of the system is illustrated in Fig. 2. When a piece of text is submitted, it is first fed into a text filter component for preprocessing, to remove parts that are not proper sentences, e.g. email headers, HTML tags, and signatures. The extracted sentences are passed on to a Link Grammar parser [22]. The basic idea with this parser is that words are connected to each other via grammatical links, e.g., if a noun is a subject to a certain verb, there



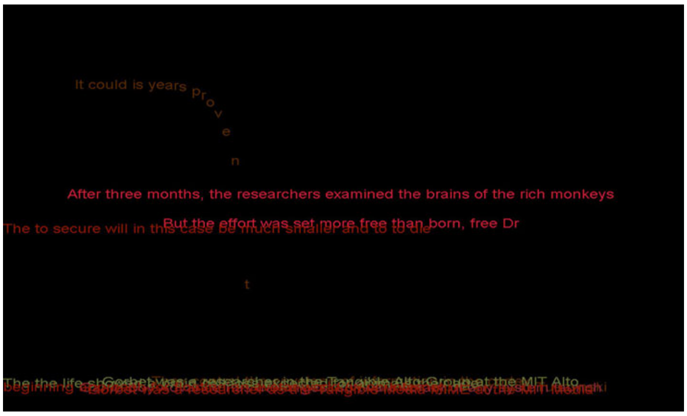


Figure 3: **Screen shot showing the "floater" visualisation**

Figure 4: **Screen shot showing the "falling leaves" visualisation**

exists a link, or a grammatical relation, between them. The parser takes one sentence at a time and identifies the syntactical function of the words and their grammatical interrelationships. The sentences are stored in a database along with the grammatical information and a timestamp.

A continuously running text synthesizer is generating a new sentence about every 10 seconds. It picks a sentence from the database and randomly selects a relation, or grammatical link, in it. Then, another sentence in the database, which contains the same relation, is retrieved. Both, or just one of the words in the selected relation are then swapped between the two sentences. This substitution is repeated up to four times before one or both of the sentences are passed on to the visualisation module. Unlike the use of totally random re-combinations used in the original "cut-up" technique, this enables the system to keep some of the original context of the material, and to increase readability by having almost grammatically correct sentences. However, since the Link Grammar parser is not always accurate, the generated sentences sometimes end up being syntactically and semantically ill-formed.

Each sentence in the database has a certain probability to be selected by the text synthesizer. The probability slowly decays as a function of time, meaning that sentences that were recently submitted have a higher probability to be selected than older ones. The probability within a certain time period, such as a few days, does not decay much. Using a scheme like this allows the ChatterBox to keep up with ongoing changes, while still using old material to keep in contact with its history.

Finally, the generated sentences are passed on to a visualisation module. Several different visualisations have been used. The first visualisation used continuously scrolling text, similar to how text is displayed at the end of a movie. Another visualisation used sentences printed in different colours appearing as floating around on a large display. Some sentences would fade in or out, some would move slowly across the screen, and sometimes different sentences would overlap (Fig. 3). Still another visualisation was based on a "falling leaves" metaphor in which the sentences were printed in different colours (typically in the colours leaves get in the fall) and appeared as slowly "falling" from the top of the screen (Fig. 4). Some sentences would fall faster than others, and some would have its letters fall off individually. The "leaves" would then whirl around at the bottom of the screen for a while before fading away. Generally, all visualisations have a relatively slow appearance in order not to attract too much attention. Several different display techniques have been used, including large plasma screens and projections on a variety of surfaces (cf. Fig. 1 and Fig. 5).

2.2 "Users"

The notion of "users" becomes somewhat problematic with the ChatterBox since it, being designed to be a part of the design of an environment, is hardly "used" at all in the sense more traditional applications are used. Considering what role people have in relation to the Chatterbox, it is possible to make a distinction between submitters and spectators. Submitters are the ones who contribute to the ChatterBox by sending in material. What material to send, is entirely up to the submitter. Spectators, on the other hand, are the ones watching the ChatterBox displays. Thus, both people working where the ChatterBox is located as well as occasional visitors can act as spectators. While most submitters also will take on the role as spectators, visitors are likely to be spectators only.

Being both a submitter and a spectator might be different from being an occasional spectator. The main reason for this assumption, is that since the texts are transformations of submitted material, knowledge about the original material can play an important role in how to make sense of the generated texts and to what extent this can be done at all. Someone who is familiar with the original material or domain will in some cases be able to see what sources have been combined or transformed (in case the transformation is not too extensive). A visitor, on the other hand, will perhaps only be able to recognise in what context or interest domain the material has its origin, for instance if it comes from an information technology research facility, a marketing company or a college school class. Still, its presentation can provide useful or entertaining cues to the local office culture. When we use the term "user" below, we refer to the people taking on both roles as submitters and spectators, in case not otherwise noted.

2.3 Privacy

The difference between an awareness system and a surveillance system is often a matter of degrees. Important aspects are, for instance, the degree of user control, the nature of the information displayed and how symmetrical the system is, i.e., if all users give and obtain the same amount and kind of information or if someone has greater access than others (cf. [13]). To the ChatterBox, users are anonymous to some extent: who submitted what and when, is not very interesting to know since everything the ChatterBox generates will be combinations of material from a number of different sources.

One way to deal with privacy issues is to rely on abstractions in some form to protect the privacy of the users, the abstract representation as such making the difference between a surveillance system and an awareness support system [6, 10, 16]. In the case of the ChatterBox, this might be a more or less efficient action, depending on the extent of the transformations, sometimes making it necessary to use other methods as well.

Although automatic collection of text material would have eliminated the need for explicit actions on behalf of the users, reducing worries about unwanted submissions is usually more important. In order to prevent private or otherwise delicate information from turning up on the display in the lunchroom, the control over the submission is put in the hands of the users in terms of sending texts to a specific email address. Still, automatic collection of material might be a possibility in some cases, especially if transformations are extensive or if the source material already is official, e.g., web pages, reports, and other public documents.

Groups

There are also privacy issues associated with groups of users. For instance, there might be information that is happily shared within a group, that they do not want others to see, such as corporate secrets or work in progress. To address this, one could either limit the access to the displays in question, shut them down during external visits or only use the ChatterBox with official material. All these variants have their drawbacks. The last one perhaps most notably so, since it will decrease the usefulness of the ChatterBox the most, in particular to the people who potentially benefit the most. However, given the way the ChatterBox works, it is probably difficult to infer detailed information about what is going on unless the original material and its context is partly known. This, in combination with the fragmentary nature of the ChatterBox texts, reduces the risks of showing it to external visitors, should the texts be based on any non-official material.

Another problem is how to deal with offensive material. In the present prototype, problems with how to, for instance, filter out offensive submissions to the ChatterBox have not been considered. However, a user group might have to take actions against submissions of offensive nature, or restricting who are allowed to contribute. It is more difficult to do something about the ChatterBox own text-generation. As the system is not to be considered as an intentional agent, any such offensive material should be seen as a coincidence.

3 Awareness, Ambience and Art

The ChatterBox can be seen as related to work on novel information display strategies such as ambient displays, since there is an intention not only to create random texts, but to create texts about something related to the environment the Chatterbox is located in. This also makes it related to work on how to support awareness about different aspects of a workplace. Below, we discuss some of the ChatterBox properties in relation to these lines of work.

3.1 Awareness

A variety of applications have been developed to support communication within physically distributed groups of people working together, by providing both a channel for communication and a context that enables users to determine when and how to engage in communication (cf. [4]). Displaying information about presence when supporting communication among physically collocated people will often not be of great importance, unless there are for example obstacles in the environment that hinder people from obtaining that information. Instead, information about who is doing what, what is happening and where, is of greater interest [6, 7]. A number of applications have been developed to support awareness in virtual environments as well, for instance applications that visualise the development of communities on the web, or how the content of on-line discussion groups change over time [5, 6].

Compared to awareness support systems, the ChatterBox presentation is based on information aggregated over longer periods of time. Further, since the original material is transformed in various ways, it will never be an accurate source of information about what has actually happened. However, it might support occasional or "informal" [3, 27] communication by providing incitements for various discussions (as were illustrated in the scenario described earlier). By placing the ChatterBox at places such as in the lunchroom or in the corridors of an office, we aim to make it readily available for people moving around. “Serendipitous” or “informal” communication is often part of the reason for people's local mobility, or “local area roaming”, i.e., when people move around in order to get a sense of what is going on [2, 3, 27].

Common to several applications supporting awareness is that they can be seen as a way of enabling users to see a “trace” of what has happened. This trace is often visualised as some sort of history, with chronologically ordered events. In the ChatterBox, events also leave a trace in the sense that information is aggregated over time and only slowly decays. While the actual phrases and sentences that are shown on the display change relatively quickly (a new sentence every 20 seconds or so), the underlying text data evolves and changes much more slowly. Compared to the transient nature of the information presented in many awareness systems, the ChatterBox has a rather slow appearance, especially in terms of how the content changes over time.

3.2 Abstract and Ambient Information Displays

An important aspect of how the information is represented to the user is what level of abstraction is being used to present it. In the case of information displays, abstraction often means a transformation of the original signal or information that reduces the level of detail in the presented information. The reasons for using abstract representations might be to create a presentation that is more easily perceived, that protects the privacy of users by not presenting too much information about them (e.g., “availability” instead of activity and location), or in order to create an aesthetically pleasing or entertaining way of showing the information.

Creating displays that are easily perceived and more "calm", at least compared to traditional GUIs, is the course taken by work on ambient media and ambient displays [14, 28 cf. also 16, 25]. Ambient displays make use of a re-mapping from the media of the original information to another, and presumably, less obtrusive media. In some cases the re-mapping itself, for instance from the number of hits on a web site to the intensity of a rain-like sound [14], constitutes such an abstraction.

A problem with abstraction through re-mapping is how to create an intuitive connection between the original information and its abstract representation. One of the seemingly more successful examples is the Dangling String [25]. In this design, the connection is rather strong: the dangling of an Ethernet cable hanging from the roof reflects the traffic frequency on the adjacent network cable. In many cases, the re-mapping seems less self-evident and thus, at least before some learning has taken place, associated with greater cognitive load (cf. [14, 16, 28]).

With the ChatterBox, we have taken a different path towards more abstract representations of the original information. Perhaps "abstraction" is a misleading description of what the ChatterBox does, but its transformation of texts serves many of the same purposes: it creates something that reflects but not necessarily presents the original information and it leaves room for protecting the privacy of the source of the presented information. Re-mapping the content of the texts submitted to the ChatterBox to, for instance, an ambient display like the Waterlamp [28] would have been a radical abstraction that would not likely have been of much use. Instead, we chose to stay with using texts, as these have been claimed to have a calm nature due to their ubiquity [24]. Another interesting property is that while the texts generated by the ChatterBox might be a bit strange and difficult to trace back to original material, this is an intended part of its design, i.e. to provide a novel view of the material.

There is at least one important difference between the strategy explored with the ChatterBox and that of ambient displays: while abstraction through re-mapping to an ambient display focuses on how to provide information about the main character of some set of information, for instance to what extent a continuous flow of information changes (e.g., [28]), the ChatterBox is all about manipulating the details of some information; the ChatterBox does not provide an overview. Further, it should not be considered as a reliable source of information, but rather as a source of inspiring, entertainingly mind-boggling "one-liners" that, nevertheless, have a strong connection to the place where it is being displayed.

3.3 Art

Art and design can influence technology design in many ways (cf. [1 , 8, 11, 15]). While the ChatterBox was influenced by the work of artists as presented in the introduction, the purpose was not to create an artistic installation *per se*, but to explore issues in human computer interaction from a slightly different perspective [19]. Given these constraints, the ChatterBox is related to work halfway between applications and art such as Gaver and Dunne's Projected Realities [8], The Interactive Poetic Garden [26], and the Dangling String [25].

4 Experiences

The prototype was tested at two different locations, for approximately one week each: at the IT-department of a large manufacturing company and at an IT-consultant company. The ChatterBox display was placed in the local lunchroom and could be seen by 30-50 people at each site, most of them working at that location. Both places see a lot of both local mobility and occasional visitors. In both cases, a projector was used to display the ChatterBox on a wall.

The ChatterBox was presented at the time of the installation, but since people are rather mobile, many potential “users” were not present at the time of the introduction. Thus, a complementary poster describing its purpose and how to submit material to it, was available next to the ChatterBox display. Since the parser we are using only accepts English texts, the users were informed that they should only submit text in English.

After a week, semi-structured interviews with eleven users were performed. As a complement, a questionnaire was sent out via email. We received 19 answers to the questionnaire. The purpose with these experiments was to find out more about the ChatterBox and to gain knowledge for future development. A common, and anticipated, comment from the users at the two offices was that the tests were too short: they did not have the time to use it long enough to evaluate it properly.

As a comparison, the ChatterBox was also tested in a setting more oriented towards entertainment and leisure, i.e., at two reception parties. Due to the rather brief nature of the experiments, the following findings should be seen as indicators that have to be followed up in future evaluations.

4.1 Results

There were numerous comments on the benefits of the ChatterBox. For instance: “It's like a scribble board that makes you think in new ways”; “It's a cool thing that gave rise to discussions”; “The poster said the ChatterBox should be seen as similar to a piece of art or a potflower. I think that describes it well. I see it as an installation. And as such, a pretty fun one.”; “Fun idea to share thoughts, questions, ideas etc.”. The ChatterBox ability to act as an incitement for discussions also received many positive comments.

Figure 5: Picture showing the ChatterBox projecting the text transformations on the wall at one of the test locations

Especially at the two offices, many users considered the transformation as problematic: “It is not very serious”; “What's the real use of this?”; “How do you know what is true and what is not?” Several users complained about the meaninglessness of technology that could not be trusted. One user expressed that the ChatterBox would add to the information overload since she felt she would have one more thing to attend to.

Some of these more sceptical users also seemed to think that the text transformations would be more useful to people working in more “creative” domains, for instance: “This random transformation of the messages seems to me more suitable to for instance an advertising agency. In that case, one could imagine to feed the system with different words and hopefully get something that can support new directions for slogans etc.”

Several users expressed their interest in having public displays providing information that they did not want, or needed, on their PC. Other users commented that they wanted to have the ChatterBox running on their personal computers, either in the background or as a screen saver. Users also felt that the visual presentation of the ChatterBox could be improved in order to make it more appealing.

While there were a number of remarks about privacy concerns, there were in fact fewer than we had anticipated. One user asked about assuring the security of the system, e.g., who would control what would be submitted, but several users expressed an interest in even using automatic collection of information, for instance from the local intranet. Many users thought that using already official material would be an interesting option.

Generally, it seems that the entertaining or inspiring properties of the ChatterBox were more successful than its support for awareness in the workplace. It also seemed that the introduction of the ChatterBox was crucial to how people perceived it. This is especially evident in the general difference between how people at the offices and at the parties perceived it. Whereas people at the offices commented about uselessness due to the lack of seriousness and accuracy, people at the parties found the very same properties entertaining. This is probably due to the fact that people do not seem to be as focused on usefulness and efficiency, properties which the ChatterBox at large lacks, at a party, as when at work. Investigating the trade-off between creating something entertaining and inspiring while still keeping its relevance and strong connection to a certain context, e.g., the work conducted at an office, is important in order to further develop strategies for how to design this type of applications.

5 Concluding Remarks

We have presented the ChatterBox as an application somewhere between a tool and a piece of art. It has not been designed to solve a particular problem, but rather to be an entertaining and inspiring resource in public spaces. We have tried to show that these aims are associated with a number of problems relevant to HCI research by discussing the properties of the ChatterBox and relating it to other work. We have also presented and discussed experiences of its use.

Future work will include more long-term studies of the ChatterBox. By comparing how it can be used, how it is perceived in different workplaces or settings and how to balance the trade-offs between creating entertaining and inspiring technology while still keeping its relevance and connection to the activities taking place where it is located, we hope to gain more knowledge about the ChatterBox and similar applications. We believe explorations in these domains of usercentered technology will play an important part in the development of the next generation of human computer interfaces.

6 Acknowledgments

The ChatterBox has its roots in a system envisioned by Lars Erik Holmquist, that would create random texts based on material collected from various web-pages, by for instance associating sentences that contain similar words.

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INFORMATIVE ART
USING AMPLIFIED ARTWORKS AS INFORMATION DISPLAYS

johan redström, tobias skog & lars hallnäs

Abstract

Informative art is computer augmented, or amplified, works of art that not only are aesthetical objects but also information displays, in as much as they dynamically reflect information about their environment. Informative art can be seen as a kind of *slow technology*, i.e. a technology that promotes moments of concentration and reflection. Our aim is to present the design space of informative art. We do so by discussing its properties and possibilities in relation to work on information visualisation, novel information display strategies, as well as art. A number of examples based on different kinds of mapping relations between information and the properties of the composition of an artwork are described.

Keywords: Art, design, augmented and amplified reality, information visualisation, ubiquitous computing.

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1 INTRODUCTION

In hotel rooms, offices and other public spaces, as well as in our homes, we often encounter pictures, posters, textiles etc. that are employed as parts of a designed environment rather than as solitary art objects. Although the distinction between design/decoration and artworks is subtle, it is clear that the pictures, posters etc. in these cases are integrated parts of a given environment.

An artwork is also a part of the environment in the sense that it can act as an information carrier giving hints about different properties of the place where they are located. The pictures, posters and other artworks in an office or in someone's home can give a visitor information about the local office culture or its owner's aesthetical preferences. Having a certain poster clearly visible to everyone entering an office, can be a way of making a statement.

In this paper we describe how other kinds of information can be mapped onto the design surface as well, making pieces of art more explicitly reflect aspects of its environment. Our aim is to present the design space of *informative art*, by discussing its properties and possibilities primarily in relation to work on interaction and information design. We will also illustrate what informative art might be like in practice, using a number of examples.

2 BACKGROUND

There are at least two reasons for complementing the desktop PC display with other techniques of providing information from the digital realm. First, the screen estate of an ordinary display is limited and already crowded with more information than most users can gain overview of. Second, since users are not always located at their desks, and since what information is relevant is highly dependent on where and when a person is doing something, users need other ways of obtaining the desired information.

The concept of ubiquitous computing [28] was introduced as a way of achieving both of these aims. As computers become available anywhere anytime, they might become a less intrusive part of our lives that poses fewer constraints on how we structure our activities, compared to the present situation. That is, if the problems associated with having information technology available everywhere all the time can be solved.

It seems that much of the design strategies developed for the ordinary PC will not hold for ubiquitous computing. One of the reasons is that the PC is designed to be one of the most important "things" to its user, being in focus and continuously attended to when in use. This might work when we have one or maybe a few devices around, but if our environment would be full of computers – as the ubiquitous computing scenario implies – constantly calling for our attention, it soon would become intolerable. Thus, it has been argued that in order to achieve the benefits of ubiquitous computing novel ways of designing information technology that can reside in the periphery of our attention, will have to be developed [29].

Information displays of various sizes placed at a variety of locations have been a part of the ubiquitous computing paradigm since the very start [27]. More recently, other media and display strategies have been explored that are more radically different from how information is presented on an ordinary PC, e.g., the *ambient displays* created by Wisneski et al [30] and Rodenstein [22], *TouchCounters* [31], *Information Percolator* [10], and abstract information displays such as [18]. With ambient media the goal has been to integrate information displays with architectural space, often in the form of more or less "tangible" presentations [12].

Figure 1: Picture showing three pieces of informative art on display at our lab.

This research constitutes an important part of the background of the work presented here. However, while the work exemplified above has resulted in novel artefacts that act as displays, our aim has been to augment a traditional notion of art objects, turning the given type of design surface into an abstract information display. Aesthetics and design methods are in focus, not the development of new display techniques (cf. [3,4]).

3 INFORMATIVE ART

With *informative art*, we refer to pieces of art that dynamically reflect, and therefore in some ways represent, information. Since this might describe almost any piece of art, given a suitable definition of 'information', it needs to be made more precise. The concept of informative art rests on a combination of the idea of using artworks to convey information, the way this was described in the introduction, with that of exploring how various objects and surfaces in physical space can be used to represent digital information. Informative art focuses on how traditional art objects, like paintings and posters, can be augmented, or *amplified* [7], and made to display information.

These amplified art objects will act as abstract information displays in the sense that the relationship between information and display surface will be a mapping between design structure and information structure rather than a effective presentation of information content. Adding a layer of information representation to an artwork can be made in several different ways. The strategy employed most commonly in the examples presented here is to map parts or properties of the composition to different sources of information, and have the composition changed over time according to the dynamics of the information.

Besides the fact that pieces of art already are used to convey information about different aspects of an environment, other properties such as placement make them suitable as information displays. The kind of artworks we are interested in amplifying, usually reside in the public spaces of an office or elsewhere where people passing by easily can take a look at them. Information displays placed at such locations have the advantage of not competing for attention with other applications, as would have been the case with yet another window on the personal computer display. Further, the information presented in informative art as described here, is not usually related to a specific person, but to a group of people or to a place. This makes it less relevant to have the information accessible on a personal computer, but more so in places where people move around in order to get a sense of what is going on. Below, we discuss some of the properties of informative art in relation to other work.

3.1 Information Visualisation

The purpose of informative art stands in contrast to using concepts and techniques developed in art to, for instance, improve application usability [2], to make more dense information visualisations possible by means of using many different layers of "brushstrokes" [14], or the seemingly more accidental pieces of art that might be the results of various visualisation techniques, such as *TreeMaps* [13]. While these and other information visualisation techniques certainly can be said to have aesthetical values, they address the problem of how to use visualisation to create an efficient and useful tool for information exploration. Informative art, on the other hand, is more about how layers of information can be added to a certain structure or composition. This is also the reason for calling it "informative *art*", and not "artisitic or decorative information". Given the importance of aesthetical considerations, informative art is related to the use of computational media in design and fine arts [16,23] (see also research groups such as [1]).

3.2 Awareness

A number of applications have been developed that support people's 'awareness' about different aspects of their environment. Especially support for spontaneous or "informal" communication among the members of a geographically distributed group by means of providing information about "what is going on" or "who is around" have been explored (cf. [5]). The rationale for such systems is that when people are co-located, physical space provides them with a number of cues, such as the sounds of people moving around or the light coming out of an office window, that seem to be of importance when engaging in spontaneous conversations. Systems more similar to the prototypes described here include for instance: *VisualWho* [6], which visualises the actions of communities on the WWW; *Chat Circles* [26], a system designed to enrich the virtual environment of online chat; and *AROMA* [18], a system that supports awareness of presence in a more abstract fashion.

Instead of making information about events taking place in physical space available in a virtual counterpart or by other means trying to build a richer context in a virtual social space, our aim has been to make otherwise invisible information available in the physical environment. Unlike conversations in the corridor, communication by means of for instance e-mail, documents, web pages etc., is invisible to everyone but the sender and receiver. By presenting cues about the such communication taking place at an office, we aim to provide a complement to the information already available (cf. the *Dangling String* [29]). The main purpose with the work presented here is not, however, to support informal communication, but to make the environment present information about the events taking place in it.

3.3 Designing for the Periphery

In many of the systems and displays discussed above, there has been a conscious effort in designing for the “periphery”, i.e., to make the systems provide background information that does not continuously force the user to actively attend to it. In this project, we have also aimed at making the surface of the display objects non-obtrusive. This has partly been done by placing the display objects at locations where they do not interfere with too many other sources of information. However, the technology involved is also “calm” in the sense of a traditional art object: it is something we intentionally look at for moments of reflection; something we concentrate on for moments of mental rest.

The notion of peripheral attention can also be problematic. In the case of Muzak™ [17] “art” is used as a background technology to manipulate and affect people in certain ways, e.g., to move faster or slower through a certain area, by presenting information designed to be perceived unconsciously. This is not the purpose with the work presented here. Information is “hidden” in the sense that it is embedded in pieces of art, but not in the sense that it is designed to be unconsciously (or *subliminally*) perceived. For instance, the changes of a certain shape in a picture might reflect changes in outdoor temperature, but this is a fact about the dynamics of the artwork that people may or may not pay any attention to, even if they find the picture as such interesting. Further, the aim with the prototypes described here is not to reduce cognitive load in terms of less demanding or more peripherally perceived displays, the way it has been argued that for instance ambient displays might help reduce information overload [30].

4 AMPLIFYING REALITY

With *amplified reality* we mean the enhancement of expression or functionality of artefacts using technology [7]. The canonical example is how audio technology such as microphones, amplifiers and loudspeakers are used to amplify the expression (e.g. loudness), or functionality (e.g. the use of feedback and distortion), of musical instruments. The use of, for instance, the electric guitar in rock music clearly illustrates how such amplification can increase the possibilities of expression.

In contrast to some *augmented reality* systems that use personal technologies such as goggles or headphones to superimpose digital information onto the real world, amplified reality is about the *public* presence of the physical artefacts themselves. In other words, if a personal wearable VR-system made up of head-up displays, earphones etc. enhances the *impressions* of the real world by adding graphics, sound etc., amplified reality is about enhancing the *expressions* of the real-world objects themselves using primarily embedded technology.

4.1 Amplified Artworks

The project described in this paper is an instance of amplified reality in as much as it is an attempt to make otherwise invisible information visible using amplified "art" objects as abstract information displays. Thus we attempt to pick up hidden information, like information about local digital communication, amplify it and present it through a public media.

By an amplified art object we simply mean a technological strengthening of a traditional notion of an art object, like a painting etc., and not an enhancement of the aesthetical expression *per se*. It might be argued that this is in fact the opposite of a strengthening, at least from an aesthetical point of view, but it is a technological strengthening of the surface in the sense that we, for instance, may work with a dynamical composition that changes its appearance over time. It is clear that this mainly is a conceptual matter since the work methods are completely different from traditional painting.

The conceptual reference to a traditional notion of an art object is of basic importance here since this reference determines the intended functionality of the amplified art objects, i.e., as objects in the given environment, they are nothing but "paintings" functioning as a kind of information display. Obviously there are clear connections here with a long tradition of investigating form and material in experimental art and design (cf. [16,23]). Curiously enough the systematic aesthetics of information technology design seem until recently, e.g. [8,9], to have been rather neglected area.

5 EXAMPLES

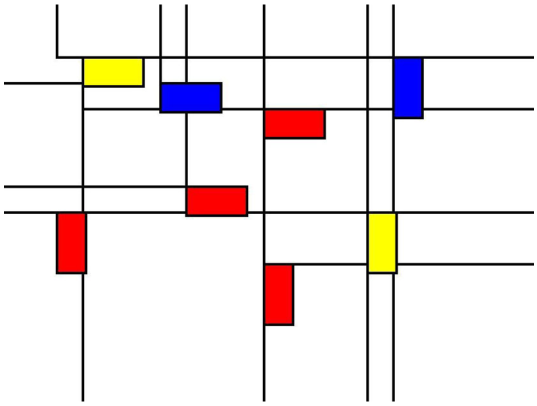
In order to explore the concept of informative art, we have developed a number of prototypes that use different kinds of mappings between the dynamics of the information to be reflected and the composition of an artwork.

5.1 Information

The examples described in this paper are all, more or less, based on information stemming from digital communication. There are, however, a number of other sources of information that might be of interest as well. For instance, the structure of many buildings makes it quite difficult to get an overview of the activities taking place. If there are large open spaces one might see where people are moving, but otherwise information such as that many people seem to be heading for a certain lecture hall thus indicating an up-coming talk or session, is hard to obtain. Information about such more or less visible events in physical space might therefore be as relevant to the design of informative art as the occurrence of digital communication, given the purpose of amplifying otherwise unavailable information.

One possible source of information would be to use photocells placed adjacent to "important" doors connecting different areas, e.g., the door to an office corridor, in order to obtain information about approximately how many people are passing by. Such an information source would still be rather abstract since no information about whom, why, or even in what direction people are moving, will be available. Still it would be an indication of activity at that location. Another example would be to use a technology similar to the ones we have used in order to support local interaction (i.e., short-range radio transceivers that enable devices to "know" what other devices are in the vicinity [20]) in order to make it possible for a work of informative art to obtain information about how many people are present in its near surroundings and change its composition accordingly. Such a mapping would also be a kind of abstract representation of activity at the location of the artwork.

Further, in some of the examples described above, time is used as a variable that is mapped to the composition. Other such general sources that might be or relevance includes light sensors to obtain the amount of daylight outside, thermometers for indoor and outdoor temperature etc. Thus, as there are a vast range of information sources that can be used in informative art, and since it is the different ways of mapping information to a composition that are the main focus in this paper, the information in the example below should be seen as illustrations that can be substituted rather easily for other kinds of information.



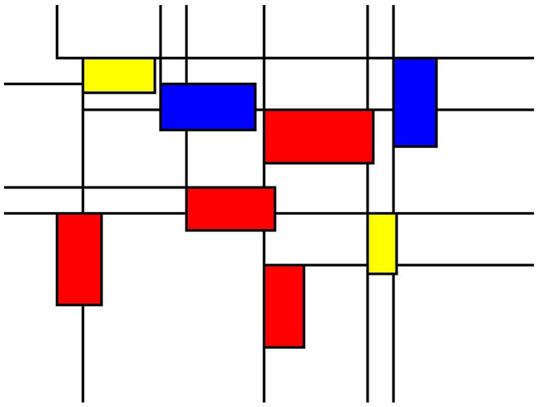


Figure 2: A Mondrianesque composition when initiated.

Figure 3: The same composition as in fig. 2 when changed according to the e-mail traffic.

E-mail and Website Traffic

Every time an e-mail passes through a mail server, information about the mail is stored in the system log. What kind information is stored varies between different kinds of mail servers, but typically each row in the log file at least contains information about sender / receiver, what time the mail passed through the server, and the size of the mail. Similar to the e-mail servers, most web servers store their traffic in a log file. The information on each row in such a log file usually consists of what document was requested, when it was requested and who (i.e. what IP-number) requested it.

To obtain the parts of this information that are required by the applications that perform the visualisations, we implemented a server application in Java, that parses the content of the log files, extracts the relevant information and finally sends it to the client(s) connected to it.

5.2 Compositions Using Colour Fields

Since many compositions make use of elements or objects with properties such as size, shape and colour, they present a number of possibilities of mapping external information onto the composition.

De Stijlistic Dynamics

Looking for inspiration for the visualisations we soon came to think of the compositions of the Dutch artist Piet Mondrian, which are based on rectangular colour fields together with black lines. Mapping information into such a composition can be done in dozens of ways. We have chosen to do a fairly straightforward mapping, where each colour field represents the e-mail traffic associated with one person (fig. 2). Whenever a person sends or receives an e-mail, the area of the field she is represented by is increased. Conversely, if someone is not involved in any e-mail communication for a period of time, the area of her field is decreased (cf. fig. 2 and fig. 3)

Every time the system starts up, a new “painting” is generated. To keep a certain structure of the compositions, each field is placed in the same place every time. The appearance of the fields, however, can vary in both shape and colour. There are three possible shapes for the fields: quadratic, standing rectangular and lying rectangular. We have chosen to use the same colours as Mondrian did for his compositions, namely red, blue, yellow and black.

Other features of the composition, such as shape and colour of the fields, or even the lines between the fields, could also be employed for mapping information into the visualisation. In order to make the visualisations as “Mondrianesque” as possible, we have chosen not to employ other colours than the ones he normally used, since varying these too much would probably steer the overall impression away from Mondrian. However, the compositions generated only have a superficial relationship to Mondrians paintings. This was also our intention, since the aim only is to make spectators associate the composition with Mondrians paintings.

A Klein Clock

The inspiration in this example comes from the *monochromes* created by the french artist Yves Klein. A monochrome is a painting using one colour – like the blue colour in Klein's late monochromes, referred to as International Klein Blue.

Let (a,b,c) be the RGB code for a given colour, i.e. the colour of a “monochrome”. We will think of the three coordinates as abstract representations of the information properties “mass”, “growth” and “flow”. As an example, one interpretation of these properties might be:

“mass” as number of e-mail, “growth” as a ratio between the number of e-mail at a short late period of the given period and the number of e-mail at an initial period of the given period, and “flow” as a ratio between the number of incoming and outgoing e-mail.

If we measure the e-mail traffic over a period of time – say the morning hours one day – with respect to some concrete interpretation of mass, growth and flow we obtain an objective information measure that can, using a suitable coding schema, be numerically coded as the RGB code of a sort of reference monochrome (a,b,c). We may now use this reference monochrome (a,b,c) as the basis for a structure of abstract colour symmetries in the sense that: (a_1,b_1,c_1) and (a_2,b_2,c_2) are symmetrical relative to (a,b,c) in case

$$(a_1,b_1,c_1) + (a_2,b_2,c_2) = (a_1+a_2,b_1+b_2,c_1+c_2) = (a,b,c)$$

Starting off with this, we can let the clock tick by adding RGB-codes modulo (a,b,c):

$$(a_3,b_3,c_3)=(a_1+a_2\text{mod}(a),b_1+b_2\text{mod}(b), c_1+c_2\text{mod}(c)),$$

on the basis of given initial codes (a_1,b_1,c_1) and (a_2,b_2,c_2).

These initial colour codes can be chosen as predictions, as descriptions of an ideal state of affairs or as measures of past information activities. In this way distinctions like objective-subjective and presence-past etc. can be introduced.

The clock is divided in two fields (fig. 4). In the left field the colour of the objectivity/presence measure is present as a static reference and the structure generated by the two initial subjectivity/past colours is ticking in the right field. Each code (a_n,b_n,c_n) for a colour that is displayed in the right field is the sum – modulo (a,b,c) – of two preceding codes $(a_{n-1},b_{n-1},c_{n-1})$ and $(a_{n-2},b_{n-2},c_{n-2})$. The rate of ticking, that is the time each colour is displayed in the right field of the clock, is

Figure 4: A Klein Clock

Figure 5: A clock displaying the flow of "objective" and "subjective" time.

a function of the two immediate preceding codes, e.g.: (C + 10 * (x + y +z)), where C is a constant and (x,y,z) is the colour to be displayed in the right field. Each coordinate will have its own rate of ticking.

Intuitively the clock is ticking towards an ideal situation when the colour displayed in the left and right fields coincide. On its way towards this ideal state the clock will display different time structures of colours such as various cycles of repetitions etc. These structures are completely determined from a mathematical point of view given the initial codes, but can from a perceptual point of view look random at first. Gradually we can learn to read the structures and get an abstract feeling for the kind of information that generated the structure and initiated the particular time structure that ticks towards its reference monochrome. If the given information structure is simple, say extremely low activity in e-mail traffic, it is rather easy to read the colour structures displayed by the clock. But if the information is more complex it will take time to figure out what is going on. The difference in structure between different initial colours is also essential. So starting with what at first looks like random noise the viewer will gradually discover a predicable structure that can be very rich. The basic ticking-algorithm discussed here can of course be varied in many ways to obtain other types of time structures.

A Clock Displaying Objective and Subjective Time

This clock is built upon the relation between the notion of “objective” and “subjective” time, represented by two colour fields (fig. 5).

To represent the “objective” time we have mapped the time to the colour of the outer surrounding field. At midnight it is black, then the colour slowly gets brighter as time goes by, and by noon it is white. It then starts to change back into black during the second half of the day. This effect is achieved by slightly changing the colour of the field once a minute. The nuance is changed according to an hour-long scheme that starts out by increasing (or, during the second half of the day, decreasing) the R value in the RGB-code by one every minute during 20 minutes, repeating this procedure with the G and B values. Thus, every hour, on the hour, the R, G and B values will be the same, making the colour of the composition a nuance of grey. In this way the darkness of the field will show what time of day it is, and the nuance (i.e., slightly red, blue or green) of the field will show how much of the hour has passed. While the very slow changes in colour and abstract code of a RGB-value will prevent most people from perceiving it, this is in fact a real clock that displays exactly what hour and what minute it is.

The notion of "subjective" time is represented by making the colour of the center field reflect the number of "events" that have passed, e.g., the amount of digital communication or the number of visitors to the office accumulated during the day. The colour of this field is updated in the same way as the other one, except that it is updated whenever an event takes place, and not when a certain time has elapsed.

5.3 Compositions Using Generative Grammars

We also wanted to use more abstract properties, such as complexity or density, of a composition to reflect information. The main problem for such a strategy is how to find a consistent way of creating different versions of a given composition. Searching for a suitable strategy, we found the techniques used in *artificial life* promising [cf. 15].

The possibility of generating increasingly complex patterns using generative grammars have raised great interest among those trying to model how complex patterns with holistic properties can arise in natural systems. So-called *Lindenmeyer systems* were developed for, and have mostly been used for, modelling the visual patterns of flowers, structural properties of plants and trees and other similar phenomena [19]. In contrast, we have used such systems to create abstract patterns, in which the repetition of shapes and structures are used to create a series of patterns which are logically related to each other.

A Lindenmeyer system is defined by a start condition, a number of production rules and a description of how to interpret them, i.e. a generative grammar which expressions are interpreted as instructions for drawing a figure or a pattern. Iterations of the rules can then be used to generate different versions of the pattern, usually of increased complexity as the number of iterations grow. Although a number of different kinds of generative grammars are employed in Lindenmeyer systems, we have only used context free grammars.

Example

The possibilities with using context free generative grammars are perhaps best described by an example. This is the definition of the pattern used in #7 (fig. 6 - fig. 9).

Axiom: X (start condition)
Rules: X: X+Y; Y:Y++[X]

Y is interpreted as "draw a straight line of length l", + as "turn 45° counterclockwise" and […] creates a branch (i.e., [pushes current state on top of stack, and] pops current state from top of stack). X is not given any interpretation in terms of a drawing instruction.

Iterations, *i*, are generated by substituting X and Y with their respective expressions. Thus, we obtain the following instructions for generating a figure:

i=0: X
i=1: X+Y
i=2: X+Y+Y++[X]
i=4: X+Y+Y++[X]+Y++[X]++[X+Y]+Y++[X]++
[X+Y]++[X+Y+Y++[X]] (fig. 6)

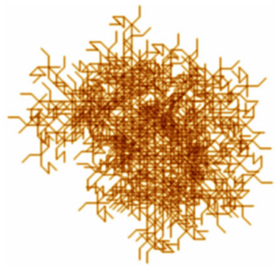


Figure 6: #7 after 4 iterations

Figure 7: #7 after 6 iterations

Figure 8: #7 after 8 iterations

Figure 9: #7 after 13 iterations

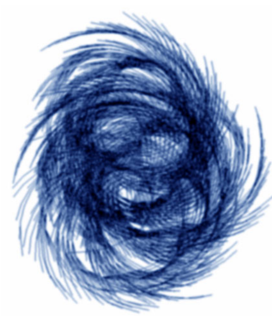


Figure 10: #6 after 7 iterations

Figure 11: #6 after 14 iterations

Figure 12: A screenshot of WebAware.

We have mapped information about the frequency of communication over e-mail as well as website traffic to the number of iterations. Beside the production rules, the choice of other variables, such as turning angle, also plays an important role to the visual appearance of a pattern (as can be seen in #6 (fig. 10 & fig. 11) in which the turning angle is much smaller, 4°, than in #7, the only other difference being the second production rule where one turn has been eliminated (Y: Y+[X])). Such variables could, of course, also be used for mapping to external information sources.

5.4 WebAware - An Example Based on Spatial Layout

Applications that make use of the “spatial” properties of information (e.g., how different parts are related to each other) are an important area of research on information visualisation. *WebAware* [24] (fig. 12) is a system that dynamically visualises the traffic on a web site and displays this visualisation in a public place. The purpose of it is to make people in a workplace aware of what is going on on their web site. WebAware falls somewhere between a more traditional information visualisation application and informative art. In being a visualisation on display in a public space, bringing electronic information into the environment, WebAware can be used as an illustration of informative art.

As a basis for the visualisation, a site map based on the external structure of the site is used. The map reflects the hierarchical directory structure of the documents on the server, i.e. documents that are situated close to each other on the server are close to each other on the screen. In this way the map can be said to reflect the “spatial” features of the tree structure.

Figure 13: An installation of the ChatterBox using a computer projector and a sheet of paper hanging from the ceiling.

In the map, each document is represented by a dot. When a web page is requested from the web server, the corresponding dot on the map is highlighted, and then, as the time lapsed since the download grows larger, will fade back to its original colour. In this way, information about the status of the current web site traffic is mapped to the colour of certain parts of the map, making them stand out from the rest of the map.

5.5 ChatterBox - An Example Based on Content

We have also experimented with informative art based on the content of e-mails and webpages. With *the ChatterBox* (fig. 13) we wanted to create an entertaining and inspiring information resource based on the e-mails sent around at an office, that also could convey information about on-going activities and projects [21].

When the ChatterBox receives e-mail (in the present version only e-mails explicitly sent to it due to privacy issues), it analyses their content and stores the sentences along with some information about what grammatical relations occur in them, in a database. In parallel to this "listening", it also "talks" continuously in the sense that it generates new sentences based on the material in the database. Finally, the generated sentences are presented on a public display.

We have experimented with a number of different ways of generating sentences. The first prototype employed a technique similar to the "cut-up" method of William S. Burroughs [25], i.e., to recombine words at random. While this strategy certainly generated new "sentences", the presentation was too difficult to make sense of given the aim to convey information about ongoing activities and projects. This led us to develop more sophisticated methods for analysing the original material and generating sentences that keep more of the original context, e.g., only substitutes parts of sentences with material from other sources. Still, the ChatterBox is capable of delivering quite unpredictable "statements" about the work at an office.

6 DISCUSSION

Below, we discuss some of the properties of informative art that might be of importance to future work, as well as when evaluating its relevance for information and interaction design.

6.1 Privacy Issues

Whenever information about people's activities is made available, privacy issues have to be addressed. In the case of informative art, certain examples might be perceived as surveillance tools. We think, however, that there are a number of reasons for believing that this will not be the case. First, the examples are symmetrical in the sense that everyone contribute with and have access to the same amount and kind of information. This is a property usually not associated with surveillance where observers usually know much more about the ones they observe, than the observed ones know about the observers.

Second, the information presented in the examples above is abstract. For instance, in the Mondrian-style examples where each coloured field represents one person it is hardly possible to see how many mails she has received and information about to or from whom the mail was sent is not available at all. In addition to that, people watching the display do not know what field represents which person. Further, the information used in the examples presented here is already available to anyone who knows how to obtain it. This is not, however, to say that privacy is not an issue in informative art, but just to point to a few possible countermeasures for protecting the privacy of the people using it (cf. [11]).

6.2 Evaluation

If one wants to evaluate a piece of informative art, what are the relevant questions to ask? In the case of an information display, issues like readability and efficiency of presentation are important criteria when evaluating a design. In the case of an artwork, evaluations in this sense are not relevant at all. Instead reflection and critical analyses are of interest. Since informative art falls somewhere in between these two categories of design, evaluating pieces of informative art might be a quite complex issue.

For instance, evaluations of the ChatterBox have shown that it can be entertaining and that its output can serve as incitements for spontaneous conversations. However, it was also clear that its usefulness as an awareness support is rather limited, since some people found the recombination of material as more of a degradation of information than as something that could inspire to new ways of looking at the original. This was especially obvious in usage contexts such as at offices, where people seemed to be focused on usefulness and efficiency, properties which the ChatterBox in many respects lack. This illustrates the difference between designing something that have information presentation as its main purpose, and informative art that is designed with other considerations in mind as well, since this might lead to less efficient information presentation.

Being clear about the intended purpose with the display, i.e., whether it is an ordinary information display or a "piece of art", is obviously of great importance and one has to choose methods for evaluation accordingly. In the end, the main purpose with any evaluation is to gain knowledge about and insights into a certain domain, often in order to be able to explore it further or to improve existing designs. In the case of informative art, evaluations are likely to contain elements from empirical user studies, as well as the kind of reflection and critical analyses normally associated with art rather than information technology.

6.3 Slow Technology

Informative art is not very suited to present important or transient information, i.e., information that has to be distributed and attended to within a short timespan. A piece of informative art should not demand continuous attention in order to see if anything interesting has happened. As mentioned above, the difference between a pice of informative art and a more traditional information display might be a matter of degrees and in order to get the most out of the former we believe one has to acknowledge the properties of ordinary pieces of art, posters, pictures etc.

Good design for user interfaces of standard applications, like search engines, should promote fast learning, easy understanding, simplicity of use, consistency etc. It is design of fast and efficient technology, of artefacts that are tools, designed for certain specific and well defined purposes. This type of design goals and its associated guidelines and design methods are not completely obvious when it comes to interaction design as *environmental* design, as room and space design. *Calm technology* [29] is an example of a different type of approach that comes out of the needs of environmental design

In informative art we would like to add a *slowness* factor. If an object of informative art should be of some interest as an object of reflection it can not be too fast and immediate. There must be something to reflect on, something to understand that has an interest in its own right. The objects can not just act as tools for fast access to information. Thus there is a need for *slow technology* here, a technology that promotes concentration and reflection.

6.4 Information Representation

Compared to work on information visualisation and ambient displays, informative art will be more about how information can be reflected in a structure designed with other criteria than information representation in focus. Thus, it is more about adding a layer of information to an existing structure, than creating a structure that will carry the information from scratch. This might be an important strategy when designing computer augmented, or amplified, environments. If a seamless integration of digital and physical should be possible, the inherent properties of existing objects have to be explored and acknowledged.

We have elaborated on a number of different ways of adding a layer of information to a composition. Properties such as the size, shape and colour of objects, as well more abstract ones, such as complexity and density of a composition, have been employed. These are only samples of possible relationships between artworks and information, and it is easy to imagine a number of other variants and combination of relations as well. For instance, in the compositions using generative grammars only one variable, the number of iterations, was mapped to an external information source. Using the content of the information to control or generate the production rules themselves, as well as mapping information to other variables, e.g., the turning angle, would open up even more possibilities in creating a close relationship between composition and information. Thus, creating the artwork would be much like creating a relation between some information and a certain presentation.

The mapping of information structure and design structure of the object surface is clearly of basic importance for an informative art object. This is first of all a matter of intrinsically aesthetical properties of the art object as such. In a piece of informative art the adequacy of information "presentation" should be a mere consequence of the fact that fundamental aesthetical problems are solved in a satisfactory manner. The art object will in this case not present information as directly as a time table at the railway station, but as inherent in the composition itself. We can for instance classify the examples presented above in terms of the type of information structure mapping involved:

- Mondrian - information maps to the size of local surfaces in the composition
- The Klein Clock - information maps to colour codes which completely defines an instance of the clock
- The compositions based on generative grammars - information maps to the iteration of the constructing rules for the system
- Web Aware - information maps to the spatial layout and colour of the composition.
- ChatterBox - explicit information maps in a distorted manner directly on to the surface of the art object

Now if a viewer does not know anything of the background of these things, what would she understand by just watching them for a while? Maybe it would be fun to watch the Mondrian-style display behaving a bit strange, changing the size of local surfaces etc, but if somebody told the observer that this object presents the e-mail traffic at the office, would that make her understand? Our intention is that the objects should function just like art objects, so 'understanding' here just means that one gets a clue to what to look for. The object will mediate between hidden information and presence in the environment. If the structure mapping gives a satisfactory solution to given aesthetical problems, then people watching it will gradually feel a clear presence of information about e-mail traffic when passing by the object or when stopping by for a moment of reflection. This knowledge about e-mail traffic will always be abstract in a certain manner, but this is also one of the main properties of the design space of informative art.

We will not argue that informative art will imply less cognitive load than traditional information displays. On the contrary, the abstract and intricate relations between properties of a composition and some source of information might sometimes be hard to perceive instantly. The benefits of informative art therefore have to be something else. We believe that one of the most interesting properties of informative art is that it opens up a design space where information presentation can be explored from a different point of view.

7 CONCLUSIONS

We have presented the concept of informative art and described its design space in relation to work on information and interaction design. Besides giving a more theoretical account of how the design of informative art differs from the design of other information displays, we have presented a number of examples. The examples were also used to illustrate some of the many different possibilities of mapping information onto a certain structure or composition.

One of the most interesting issues in the design of informative art is the fact that information representation has to be achieved according to quite different criteria compared to more traditional information visualisation. In information visualisation, the structure or composition that carries the information is optimised with regards to the information in question. In informative art, on the other hand, the visualisation has to comply to criteria such as that the overall composition should be motivated from an aesthetical point of view and that the design should be able to fill the role or niche of an art object in a certain space.

Finally, informative art can be seen as a kind of *slow technology* that encourages moments of reflection and concentration in order to understand it. Thus, it stands in contrast to other information displays that are designed with readability and efficiency in mind. Informative art is not about reducing cognitive load, but about inspiring and providing food, rather than fast food, for thought.

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SLOW TECHNOLOGY
DESIGNING FOR REFLECTION

lars hallnäs & johan redström

Abstract

As computers are increasingly woven into the fabric of everyday life, interaction design may have to change – from creating only fast and efficient tools to be used during a limited time in specific situations, to creating technology that surrounds us and therefore is a part of our activities for long periods of time. We present *slow technology*: a design agenda for technology aimed at reflection and moments of mental rest rather than efficiency in performance. The aim of this paper is to develop a design philosophy for slow technology, to discuss general design principles and to revisit some basic issues in interaction design from a more philosophical point of view. We discuss examples of *soniture* and *informative art* as instances of slow technology and as examples on how the design principles can be applied in practice.

Keywords: slow technology, design, human-computer interaction, ubiquitous computing, soniture, informative art.

1 Introduction

As the use of a certain kind of object changes, there is often a need to reconsider the principles behind its design. Often, this leads to an extensive pluralism in terms of design principles and goals as the many situations and user groups have incompatible demands and expectations. Until recently, the main purpose with information technology has been to make people more efficient when carrying out certain tasks. This is, given the background of computers in office automation and efficient scientific calculations, a highly reasonable design agenda. However, as information technology now is being used far outside its origin in the office environment and scientific computation centres, and no longer by a selected group of business professionals and scientists, new demands on the design of such technology arise.

Computers have, for instance, been used in entertainment for a long time. Computer games is now one of the driving forces in hardware development. Artists and composers frequently use computers as medium of expression, creating genres such as interactive art and electro-acoustic music (cf. [1,2]). These areas of use have posed special demands on the technology, leading to development of special interface components such as joysticks, drawing tablets and MIDI keyboards. Development of specialised interface components is now an important part of HCI research (cf. [3]). Still, much development has been concentrated on the computer as a tool to be used in specific situation to accomplish a certain task.

When computers become increasingly ubiquitous, some of them will turn from being tools explicitly used in specific situations to being more or less continuously present as a part of a designed environment. One of the aspects of this transition is that the time perspective changes from just encompassing the moment of explicit use to the longer periods of time associated with dwelling. We can compare this to the use of a chair: designing only for the situation when a person is actually sitting down in a chair, is quite different from designing for the long periods of time, during which people only sometimes sit down in the chair, when the chair is used as a part of the environment. The second case implies that not only the affordance of being able to sit upon is of relevance, but also the aesthetics of its design, its integration with the rest of the environment etc.

Researchers have worked on a variety of aspects of the integration of computing technology and the physical environment (cf. [4]). *Ubiquitous computing* is concerned with how to support people with the relevant computational resources wherever they are [5]. Work on *augmented reality* has been exploring how digital information can be superimposed on, and integrated with, real-world objects and environments (e.g. [6,7]). Examples of *calm technology* [8] and *ambient media* [9] have been designed to allow for a smooth integration of digital information and physical space, taking advantage of human peripheral attention. For instance, a number of novel information displays that aim to reduce cognitive load and give users more background access to information have been developed [10,11,12].

Calm technology and ambient displays are designed to reside in the periphery of our attention, continuously providing us with contextual information without demanding a conscious effort on our behalf. However, we believe that we do not only need to create calm technology, we *also* need to actively promote moments of reflection and mental rest in a more and more rapidly changing environment. There is clearly a challenge for new technology to answer this call.

Figure 1: Picture showing three pieces of informative art.

2 A Design Philosophy for Slow Technology

> Design-by-drawing, the traditional design method, depends almost completely upon accurate modelling of dimension in space. The time dimension, if we may call it that, is left to take care of itself. As the scale of designing is increased (from the designing of objects to the designing of systems, programs, flows, communications, communities, and the like) the way things are used, their life-cycles, become as much designed as do their shapes. At this point designers need to acknowledge their relative ignorance of "temporal design" and can perhaps learn from the "time arts" (music, dance, theatre, film, novel, poetry, etc.) how to compose-in-time with some sense of beauty. To design in time is, more so than when designing objects, to design life itself, the very form of existence, and surely calls for a gentler touch than can be felt in the insensitive forms of our production-systems, legal-systems, timetables, schedules, distribution-systems, etc.
> J.C Jones, [13, p. xxxii]

Interaction in environmental design has a natural foundation in how we understand and relate to the environment. We continuously change our behaviours in response to the environment, thereby in turn also changing the environment. Architects, interior designers, artists and others have long been working on how technology and design can initiate such changes in various ways, but it is not until recently that issues in environmental design has gained interest to the HCI community (cf. [14,15]). What are the characteristics of information and computing technology that initiate changes towards a more reflective environment? One partial answer to this question is that such technology is *slow* in nature.

Imagine an electronic doorbell that plays short fragments of a very long melody each time we press the doorbell button. To fully grasp the doorbell through its behaviour, we have to stop and reflect for a moment each time it rings and only over time we can grasp the whole melody. It is technology that claims time. Is this "slow" doorbell a better doorbell than the ordinary one playing the same two or three tones over and over again? The difference in aesthetics between the two doorbells is a difference in philosophy of design; the "slow" doorbell is not designed to be "just" an efficient signalling mechanism for non-reflective use, but rather an artefact that through its *expression* and slow appearance puts reflective "use" in focus. It is a doorbell designed for reflection in a world of expressions using time and presence as key parameters.

We can compare the two doorbells with, say, the distinction between fast-food like ready-made hamburgers and a gourmet meal. It is food to eat in both cases, but there is a fundamental difference in appearance. While the readymade hamburger is all about fast efficient uniformity – the mechanisation of eating – gourmet cuisine is slow food, in terms of both preparation and eating, that invites us to reflect on the art of cooking as well as the art of eating. It is in a certain sense a question about functionality versus aesthetics.

There is an analogous distinction between fast technology and slow technology. Good design of tools used for certain specific purposes may be characterised in terms of ease of use, fast learning, efficiency, immediate "visible" results etc. (cf. [16]). This is *fast* technology: efficiency in functionality in respect to a well-defined task. With fast technology we aim to take away time. We aim to *take away* time both in terms of making the user more efficient when working (the task taking less time) and making the artefact as such as fast and easy to use as possible; we ask ourselves questions such as how long it takes the average user to perform a certain action or to learn how to use the given technology. For instance, the time for a long journey abroad to meet somebody can be taken away through a single phone call; the time for reflecting on the syntax of language may disappear through a single mouse click in a word processor. Now, technology can also be *slow* in various ways:

i) takes time to learn how it works,

ii) takes time to understand why it works the way it works,

iii) takes time to apply it,

iv) takes time to see what it is,

v) takes time to find out the consequences of using it.

The reason for this slowness might be bad design or complexity of tasks. Such unintentional slowness often results in frustration on behalf of the user. But i - v could also be a description of the basic and intentional slowness in learning/understanding (i and ii) and in presence (iii, iv and v) of a work of art, a piece of music or any other object designed for reflection. All design with deep roots in art is concerned with amplifying the presence of things to make them into something more than efficient tools for specific well-defined tasks [17,18]. The expression of design then invites to reflection, but it is slow technology only with respect to true use of a certain thing; time and/or reflective presence are not necessarily key design notions.

Slow technology is technology, which is slow in various degrees in respect to i - v. What is important to note here is that the distinction between fast and slow technology is not a distinction in terms of time perception; it is a metaphorical distinction that has to do with time presence. When we use a thing as an efficient tool time disappears, i.e. we get things done. Accepting an invitation for reflection inherent in the design means on the other hand that time will appear, i.e. we open up for time presence.

A key issue in slow technology, as a design philosophy, is that we should use slowness in learning, understanding and presence to give people time to think and reflect. Using such an object should not be time consuming, but time productive; we should get time for new reflective activities. It is not technology for compressing time to do given tasks, but technology supplying time for doing new things. It is technology that is useless for fast and impressive demos; to see what it is takes time.

Slow technology *can* be technology where the aesthetics of functionality, i.e., that the expression of functionality as such, rather than its objectives, is in focus. It is design concerned with how we relate to the expression of technology itself as we use it to do certain things. The functionality of a doorbell is concerned with telling us that someone is at the door and wants us to open it. Our "slow" doorbell is designed with focus on how we relate to the possible expressions of this doorbell-functionality. Here, slow technology design is applied aesthetics, the aesthetics of presence, inner design logic, use, basic technology, reflective content etc. Slowness then comes as a consequence of a techno-aesthetical design philosophy that focuses on reflective and conscious use of the technology as such. Slow technology *can also* be technology where slowness of appearance and presence simply is inherent in the design for various reasons beyond pure aesthetics of functionality, design where time is a central and explicit notion. This is technology with focus on time presence.

If slowness comes as a result of the concentration on aesthetics, it might well be that the given thing at the same time is an effective tool, i.e. slowness comes from reflection on aesthetical aspects and changing perspective we use the same thing to efficiently accomplish a given task. The delicate handicraft and design of a mechanical watch invites to reflection on technology making it slow in appearance, but we also use the watch for fast access to time. We collect such watches as a pure act of reflection on technology. In a certain sense we "use" things in different modes as we switch back and forth between a slow and a fast perspective. There is nothing strange with this as we design things that somehow have a definition in terms of functionality.

Slow technology shares the interest in a tight integration between computational media and the rest of the designed physical environment with approaches such as calm technology and ambient media. However, slow technology differs in that is not supposed to reduce cognitive load or to make digital information and computational resources more readily available. Slow technology is not about making technology invisible, but about exposing technology in a way that encourages people to reflect and think about it. This design challenge is, among other things, a call for a more conscious aesthetics in technology [3,19,20], i.e. technology is not just solutions to specific technical problems, but also things with specific expressions situated in our living environments.

3 Examples and Projects

Typical examples of artefacts made to encourage reflection are art and music, especially as found at art exhibitions and in concert halls. In slow technology, however, the use of nearly ubiquitous information technology in everyday life is in focus. Transitions, back and forth, from these traditional places designated for reflection and meditation to everyday-life environments are often present in environmental design. A house is built as part of our everyday-life environment, but at the same time its architecture, interior design etc. can be conceived as works of art. We can change our perspective by looking at the house as an art object and not just as a building in which our office is situated. Then, the house is no longer "just" a heated place that keeps the rain out where we can sit down and do our work, but it is also a complex unity of interesting expressions of which many have their roots in the reflective environments of artistic work. In these transitions from the "art-world" to the "everyday-life-world" we bring certain aspects of the expression of things as art objects to the design of everyday things. In the design programme of slow technology we have in mind, we have distinguished three such aspects – *reflective technology*, *time technology* and *amplified environments* – each making up a specific design theme in the programme.

Reflective Technology

This theme concerns the design of technology that both invites to reflection and at the same time is reflective in its expression. The basic challenge is to design technology that in its elementary expression opens up for reflection and ask questions about its being as a piece of technology. It is technology that could be awkward if it is used without reflection, i.e., if we just try to take it for granted as a "simple" tool.

Technology in its early development often has a functionality expression that reminds us of its own being as a specific piece of technology. The technology is "new" thus still an event and not yet perfect in functionality and slim design – just take the very first computer technology as a typical example. In these early stages of development awareness of the elementary expression of given technology is still present. Later on, this is something that often seems to be lost in the expressions of fast and efficient technology. Here, the call for slow technology is to use slow design expression as an instrument to make room for and invite to reflection; to use a slow presence of elementary technology as a tool for making reflection inherent in design expression.

Time technology

This theme concerns the design of technology that through its expression amplifies the presence –not the absence– of time. The basic challenge is to design technology that somehow seems to give us time for doing certain things. It should not be technology that is tiresome and time consuming, but technology that stretches time and slow things down. A good music instrument is typical example of such technology. If you master the art of playing the violin a good violin is a piece of technology that through its expression in use, for example in playing a partita by Bach, certainly amplifies the presence of time. In these theme, the call for slow technology is to design technology that in true use reveals a slow expression of present time.

Amplified environments

This theme concerns the design of technological settings for the enlargement and *amplification* of given environments. With *amplified reality* [21] we mean the use of computers and other technologies to enhance the *expressions* and functionality of existing artefacts (or kinds of artefacts). A typical example is electronic audio technology such as the combination of microphones, amplifiers and loudspeakers that enables to musicians to perform in ways that are not possible with non-amplified acoustical instruments. The basic challenge is to design settings that amplify the expressions of a given environment in such a way that it in practice is enlarged in space or time. The call for slow technology is to use slow design expression to amplify given environments in time.

Below, we present some examples of slow technology. The examples fall into two categories, *sonitures* and *informative art*.

3.1 Soniture

With *soniture*, we mean the more or less movable things in a room that gives the room its sounds, the sounds that equip it for living and makes into the particular room it is. (Compare with furniture: the movable things in a room etc, which equip it for living, as chairs, beds etc.)

Sound is always the sound *of* something, or sounds *from* something. Something starts the patterns of air pressure oscillations that reach us as sounds. Some of these sounds and their sources define an environment; they constitute the sonitures of the given environment. Soniture can, for instance, be an old clock ticking and ringing, a refrigerator, a blender or a door where the hinges needs oiling. Soniture is, however, not only furniture, or the walls and the floor of a room – it can also be sound installations, people moving around, etc.

The absence of sound is a property of furniture and other environmental things as fast practical tools. Using the sound as a central property of material amplifies the presence of things and makes learning and understanding slower. Consider the "nightingale floor" of Japanese Shogun castles, a singing floor that was built to warn against intruders, or a rocking chair with a complex sounding behaviour. In these cases, the fact that using furniture, living in a house, walking on the floor etc. all are a form of interaction with the environment is made more explicit through the use of sound.

If we think of the floor as a piece of soniture we view the floor as an instrument in the orchestra of a given room, the orchestra that plays all the familiar songs that are connected with the room; we focus on a certain elementary property of the floor as it continuously helps to build the room. Soniture is, just like furniture, an aspect of the presence and expression of things – thus soniture is not a name for "sonic furniture" [22]. Modern computer and audio technology has vastly increased the possibilities for the design of soniture. However, there are still many challenges when it comes to designing old-fashioned furniture with focus on the sound of material.

Designing soniture as slow technology can be a matter of using sound as one central property of material for building furniture or it can be a matter of using modern audio technology in combination with computing technology to amplify and redefine given environments (cf. "multimodal environments" [23]). Below we present some examples of soniture. In many cases the differences between creating a piece of music, an installation (e.g. [24]) creating a certain soundscape [25] or building a piece of soniture is a matter of degrees. However, the intersections between these areas of use also points to slow technology as an attempt to join ideas from art, environment and interior design, and the development of information technology.

SoundMirrors

In "Flashbacks", several microphones are used to record sound fragments in a corridor at an office. These fragments are then played back through loudspeakers in the same corridor with varying time delay – the recorded sound fragments are not saved, creating something similar to a "slow mirror". The time series of fragments and delays have a certain structure that is possible to understand through careful reflection on what happens over a long period of time. Thus it is possible to predict when this audio mirror reflects the present sounds or when it will not. At first all we notice is that sounds are played back, then we recognise that these sounds come from earlier sound events in the very same corridor. Later we can recognise a certain well-defined structure in time, a class of patterns that makes the capture-playback series into an understandable soniture.

There are several question about technology that the SoundMirror is aimed to expose. The basic design question asked in the SoundMirror experiment is: how does this mixture of very simple audio technology with a more sophisticated time composition function as a basis for a reflective audio environmental design. It is also designed to make people reflect on how soniture can be used to amplify the notion of a corridor as a public place.

In order to obtain a structure sufficiently rich and complex to gain interest over a long period of time we used multiple layers of capture and playback. Studio monitors with much the same audio level as the level of ordinary conversation in the corridor were used in order to obtain a "close" sound that worked well as a part of the given environment. Further, the placement of microphones and

Figure 2: Picture showing a SoundMirror.

loudspeakers are critical. In our experiment we did not attempt to hide them, making them act as visual markers of the fact that a recording was taking place. However, one might want to hide all microphones and loudspeakers ensuring that the SoundMirror becomes a soniture that is more integrated with the given environment. One could also imagine rooms and corridors that are designed with sonitures, such as the SoundMirror, already integrated in the interiors of the building.

SoundLamps – the Art of Concentration.

Consider the two following equations:

light = sound

dark = silence

We can think of a lamp as something that brings light into darkness. Thus, a SoundLamp is something that brings sound into where silence resides. In terms of being a piece of soniture, a SoundLamp is based on sounds that emerge whenever it is completely "dark", i.e. completely silent with respect to the background noise in the room. As with ordinary lamps, you can turn it on whenever you want, but you will only see, or in this case hear, it when it is dark, or silent, enough. Thus to "see" the light from the lamp you have to concentrate on being silent, an act of intensive reflection on the sounds you and others in the room make. Compare this with music for meditation and concentration, like Stockhausen's "Aus den Sieben Tagen" [26].

SoundLamps can be implemented in various ways. One can use a low-level sound that is difficult to hear, ensuring that one has to be almost completely silent in order to here the sound. Further, we can use headphones for the sounds we want to hear, we can use extremely directed speakers, or we can engage in building complex acoustic models of the given room trying to isolate the sound of the lamp from all background "noise".

Furniture and Soniture – the Sound of Presence

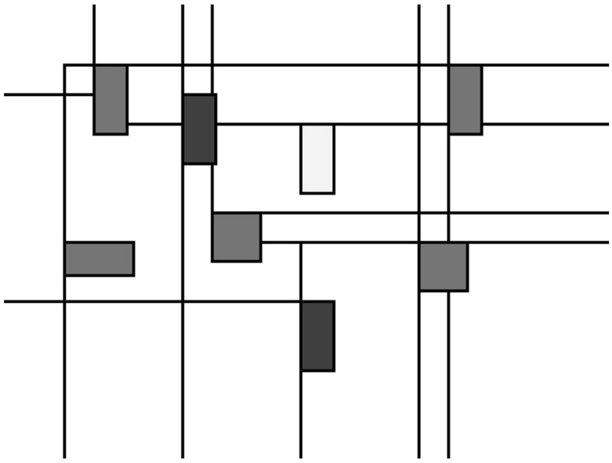
The issue here is to use computer technology in combination with sensor and audio technology to build floors, walls and other things as resonance resources amplifying the sound presence of people in a room. One could for instance use sensor technology to implement an "active" floor (cf. [27]) that can inform us about the history of presence in the room; am I walking on a part of the floor where many people recently have walked? We could implement sonitures representing aspects like "clean", "dusty", "dirty" or "worn". These aspects all have to do with changes over time. The audio expression of the floor is slow, just as an old fashioned floor it gradually changes its expression as time and people goes by.

Build a rocking chair with focus on the sound of material in shaping the chair. The objective should be to look for rich, distinct, controlled and unique sounds that defines sitting in this particular chair. The chair will not just be something practical, something to sit on, but a chair where distinct presence and "personality" is amplified through the sounds that comes with it. The chair as a piece of soniture with a rich expression makes the chair into a "slow" chair where the aesthetics of sitting will be in focus. This is closely related to the sonic furniture of AudioLives [22], which gives an example of how we can build a sort of soniture, for social interactions in the workplace, using modern computing technology.

3.2 Informative Art

Posters, pictures, paintings etc. are often used to furnish the walls of our homes, offices and other places. Partly they are employed for their aesthetical properties, but perhaps even more because of their function as decorative objects that help creating a certain ambience. A certain picture or poster might also serve as a kind of statement that enables visitors to get a clue of what the place and the people living or working

Figure 3: Picture showing three pieces of informative art.From left to right: WebAware [29], and two abstract clocks [28].



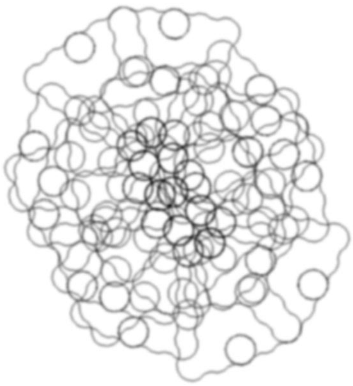


Figure 4: Screenshot showing a Mondrian-like visualisation.

Figure 5: Screenshot showing a visualisation based on a Lindenmayer-system

there might be like. With *informative art* [28], we have tried to "amplify" an art object's capability to present information about its location. This can be achieved by mapping information to changes in the structure of the composition, colour scheme etc.

In more traditional forms of information visualisation, the design problem is how to create a structure that represents the information as efficiently and readable as possible. In informative art, these structures are often more or less given by the conventions of what posters and pictures might be like in order to fit into the desired environment, or by some other set of aesthetical preferences. The main problem is how to make these structures carry the desired set of information. It should also be noted that the issue in informative art is not to create art *per se* (cf. [1,2]), but to explore the design space of information presentation from a different point of view (cf. [30]).

Abstract Information Displays.

We have experimented with displaying time structures in terms of various "clocks", for example a clock inspired by Y. Kleins monochromes where colours and time structures interprets certain properties of given information and a clock slowly displaying time in terms of small changes in colour of a simple geometrical structure [28]. Inspired by paintings of P. Mondrian we have experimented with mapping the dynamics of information structures onto the geometrics of Mondrian-like displays [28]. We have also used techniques such as generative grammars and Lindenmayer systems (e.g. [31]) to be able to map information to the complexity of a pattern or composition [28].

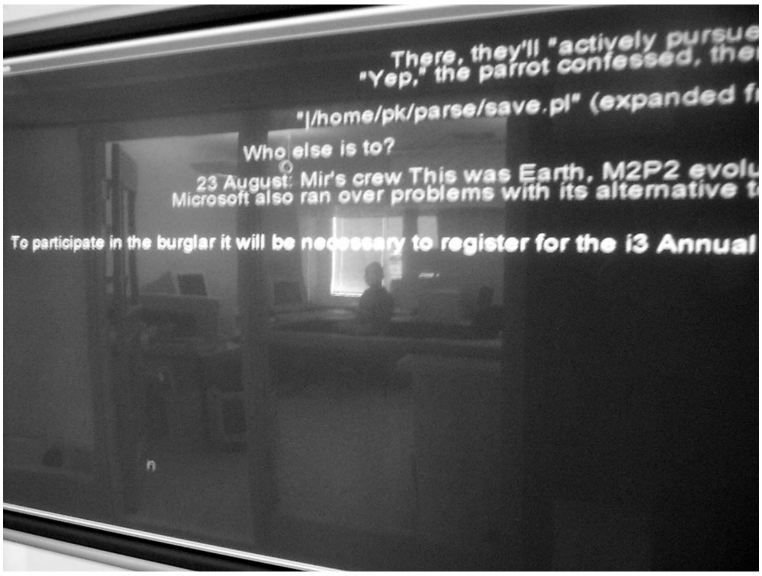


Figure 6: Picture showing the ChatterBox.

The ChatterBox

We have also created informative art that use slightly more complex sources of information, like the ChatterBox [32]. The ChatterBox continuously "listens" for the e-mails and electronic documents that are sent around at, e.g., an office (privacy issues naturally restricting the extent and nature of this "overhearing"). It then analyses the material and stores the sentences and information about syntax in a database. In parallel, the ChatterBox continuously "talks" by generating novel sentences based on the material in the database. It does so by recombining material by swapping words between sentences. Finally, the sentences are visualised in the corridor, the lunchroom or another public place, so that people can take a quick glance at it while passing by. We have experimented with different kinds of visualisations, including appearances based on how credits are displayed after a movie, and visualisations based on a "falling autumn leaves"-metaphor, in which letters, words and sentences would fall from the top of the screen at various speeds and then whirl around at the bottom.

The basic idea with the ChatterBox was to provide entertaining and inspiring variations of the material produced at an office. However, it also serves as a very slow tool for workplace awareness in the sense that each time one takes a look at it, a small and distorted fragment of the original material will be presented. At first, the appearance of the ChatterBox will seem as a rather ordinary random text-generator, but over time, one will be able to recognise parts of sentences, words and sentence structures. Over time, one will slowly form an understanding of the underlying material and finally even an understanding of the rules according to which the sentences are generated. Even visitors, who are not very familiar with the original material submitted to the ChatterBox, will over time be able to form some kind of understanding of what is going on at the office, in as much as these activities are reflected in the material the ChatterBox is working on. The ChatterBox serves as an example of slow technology both in terms of its visual appearance and in terms of how we come to perceive and understand it over time.

4 Form and Function

A basic principle of slow technology is to *amplify the presence* of things to make them into something more than just a silent tool for fast access to something else. This amplification is not just a matter of aesthetical surface, but concerns the whole thing as it is used. We do not talk about functionality *and* design, but about the complete expression of a thing as it appears in the given context.

In the case of a word processor it is easy to point out its function; it is a tool that supports its user when writing and otherwise constructing documents. So when designing things that should invite to and make room for reflection it seems obvious that function is all about supporting reflection on some given issue. Then, why not put up a sign saying "PLEASE REFLECT ON X"? One basic reason is that the sign through its message –its expression– does not give any precise meaning to the intended act of reflecting. Assume the function of a painting hanging on the wall in my room, as it seems to be used, is to make me happy, or at least to put me into a mood of smiling. Why is it not enough with a reminder sign on the wall saying in capital letters "SMILE" or "THINK OF YOUR FAVORITE PAINTING BY MATISSE" etc.? A key reason why this substitution is pointless is that the reminder sign is very imprecise in telling me what my favourite painting by Matisse is or why I should smile. It is simply the expression of the Matisse painting itself –or probably a reproduction– hanging on the wall that is important. The function of a thing designed to invite to and make room for reflection is inherent in the precise meaning of reflecting that is given by the total expression of the given thing; function is inherent in design expression.

In slow technology as environmental interaction design this interplay between form and function is clear; form is the process to learn and realise function, the structure of building a living environment. We may think of form as that structure which presents, the design expression, i.e. the structure of appearance and presence. Thus in slow technology form brings forth function. But form is in the present context not necessarily a consequence of the primary functionality of an object. Take for instance a slow mirror, an object that only very gradually turns into a mirror and only gradually deletes the mirrored image. It functions as a mirror, but this "mirror" appears in a form that to some extent hides the basic functionality of a mirror. This is similar to how a puzzle, due to its form as a puzzle, hides a picture. In this case, form covers the primary functionality of an object as a bearer of slowness.

5 Evaluating Slow Technology

One of the implications of designing for "presence" instead of "use", is that evaluations will have to change as well. When evaluating a certain design given the objectives specific to slow technology, what are the relevant questions to ask? The need for building prototypes and to expose them to real-world settings are likely to be as important to slow technology as it is to any other practical study of how to develop principles for interaction design.

In the present context the question about good design is intimately interwoven with questions concerning what a given designed thing really is. In the case of "tools" it can be argued that the basic of a tool is understanding how it is used – a tool is always something that is used *for* something. In the case of other artefacts, such as works of art, this basic understanding has to be something else. One cannot explain what a symphony by Beethoven is, as a piece of art, by empirical studies of a collection of concert visitors. To answer this question is more like formulating the theory, or model, of its inner logic, aesthetics etc. on which a sensible empirical study can rest.

The examples of slow technology presented here are neither works of art, nor tools. They share, however, properties with both extremes. We have argued that good design of slow technology is primarily about inner logic and aesthetics, since these seem to be key factors in creating something that can serve as an incitement for reflection. Design given these objectives will have to be evaluated by investigating the design, perhaps in a way similar to the methods developed in art critique: cultivating evaluation as the art of explanation and understanding.

Evaluations of slow technology will, however, also share characteristics with more typical interaction design methodologies since we aim to create building blocks that people can use to furnish their environments. The empirical evaluations we have done have clearly showed that slow technology has to be carefully framed and introduced in order not be perceived merely as some poorly designed and, as a result, useless tools. Part of the problem is how to introduce a kind of technology behaving in a way that we normally would expect to find at an arts exhibition or when using a musical instrument, in the context of information technology in everyday life. For instance, we have tried the ChatterBox in a range of different settings with differing results [32]. When used at offices, many people perceived it as inefficient and the transformation of information as more of degradation than as inspiration. The very same prototype used at a reception party made people think about, laugh at and talk about its texts.

6 Developing Guidelines for Slow Technology

One of the basic ideas behind the examples of slow technology is to use simplicity in material in combination with complexity of form. Much design, especially of digital media, is about creating something that is immediately appealing and impressive. This is not the case with slow technology. Taking the ChatterBox as an example, the purpose is not to create an exciting visual presentation. Neither is it to create an innovative text generator or natural language parser. Although these are important parts of system, the main purpose is to present the material submitted to ChatterBox in a special way, namely as recombinations and transformations of partly familiar fragments of texts. This makes the ChatterBox less impressive from a technological point of view, and many "users" started out with the question "So what?". This is nevertheless a starting point for reflecting upon it: What does it do? Where does this and that sentence come from? etc. Similar questions can be asked about the other examples.

Simplicity in material invites people to reflect when there is an obvious complexity in form. The modest appearance of the ChatterBox or the SoundMirror does not stand in the way when one wants to find out more about their inner workings – their appearance even indicate that there must be something more to them than this appearance. The combination of a modest and a slow appearance is also what makes slow technology interesting in the case of environmental design - when trying to make technology interesting and stimulating when present over long periods of time. Given the experiences presented here, we propose two basic guidelines for slow technology:

(F) Focus on slowness of appearance (materialisation, manifestation) and presence – the slow materialisation and design presence of form,

(M) Focus on aesthetics of material and use simple basic tools of modern technology – the clear and simple design presence of material.

The design should give time for reflection through its slow form–presence and invite us to reflect through its clear, distinct and simple material–expression. It is a combination of simplicity in material with a subtle complexity in form focusing on time as a basic element of composition. Technology should bring forth the material not hide it.

7 Concluding Remarks

Interaction design in the area of HCI mainly concerns itself with tools and work methods for certain specific tasks. But in a more general sense interaction design can also be concerned with the design of an environment in which these tasks occur. This is interaction design in the sense that we design structures within which we express presence and build our "work-worlds" and "life-worlds" through interaction with the environment. The notion of slow technology is, just like calm technology, a kind of leitmotif for this type of interaction design. It brings a uniform approach to basic notions like appearance, presence, expression, environmental interaction etc., as well as to the inherent relation between form and function in environmental design. Slowness as a key factor that could bring forth, and make room for, reflection. The idea with a design leitmotif is to conceptualise the design style, the form of expression.

It is clear that there is a point of convergence of technology, design and art in a design philosophy like slow technology (cf. [33,34,35]). In practice, such a convergence can take on many different routes, ranging from examples such as Bauhaus to more modest forms of collaboration as in various artist-in-residence programs [19]. Slow technology should not be seen just as a call for more creativity or artistic expression in a world of information technology, but as an attempt to revisit some basic problems in interface design from a perspective that bears on ideas about environmental design derived from several different disciplines. It is also an attempt to discuss the foundations for design as such in information technology (cf. [36,37]).

The importance of aesthetics in slow technology is a consequence of the design objective, as is the focus on the inner logic of the design. It might be easy to confuse any study of technology with the design objective of functioning as incitements for reflection, with art. This might be because of the predominance of the study and development of tools. However, if we instead turn to architecture or interior design, where the environment as a whole is in focus, the combination of aesthetics and more technological issues is central. As computers increasingly become a part of our everyday lives, such a combination of interests is likely to be of great importance to interaction design.

We believe that the transition from, or rather complement to, the perspective on technology as "tool" to a perspective on information technology as being a part of a complex designed and inhabited environment will be important to future design methodologies [38]. Not only does this imply that we have to engage in a range of issues concerning the role and effects of new technology, it also opens up many interesting new possibilities. One such possibility is technology, such as slow technology, that is not "used" at all but nevertheless is a part of the environment, adding to its ambience and supporting various activities taking place in it.

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EXPRESSIONS
TOWARDS A DESIGN PRACTICE OF SLOW TECHNOLOGY

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Abstract

As computer use increasingly influence everyday life, we need to complement our knowledge of the computer as a technology for creating fast and efficient tools, with other perspectives on information technology. We describe *Slow Technology*, technology aimed at promoting moments of reflection and mental rest. Taking the design programme of Slow Technology as our starting point, we have explored expressions of the acts of reading and writing information using computers in everyday life. A number of design examples including the Fan House, the Chest of Drawers, the Lamp Foot and the Fabric Door, have been created. The purpose with these examples has not been to create new information displays, interaction devices, artworks or products, but to create a basic collection of examples that

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can support systematic investigation of the aesthetics of computational technology as material for the design of everyday things. Experiences from the design and exhibition of these examples are presented as design leitmotifs for future work with Slow Technology.

Keywords: Experimental design, computer aesthetics, design theory, design research, Slow Technology

1 Introduction

The general agenda of HCI research is to study, describe and design the interaction between people and computational artefacts. In practice, this is often done in a limited domain of computational tools specifically created to aid people in performing a certain set of, primarily work-related, tasks. The knowledge gained from using computers to create efficient tools at the workplace can be applicable in other domains, but there are aspects of interaction design falling outside a strict focus on functionality and usability that still are very important in the design of everyday things.

Consider, for instance, the design of a doorknob. The basic functionality of a doorknob can be expressed through clear affordances that support the use of the doorknob as a fast and efficient tool for opening the door. However, the act of opening the door also has a certain expression that we may reflect upon when we open the door and enter a room. This expression is not captured by a reference to pure functionality; it concerns the aesthetics of a doorknob in use. During the design process, we must at some point, explicitly or implicitly, consider this question – the aesthetics of things in use is inherent in the foundation of modern design. As computers increasingly pervade our everyday lives, the aesthetics of things in use will gain importance in human-computer interaction design as well.

The basic working hypothesis adopted here, is that we have to investigate the properties of computational technology as material for design to gain an understanding of how it can build the appearance of everyday computational things. This kind of research is often carried out in terms of experimental design work: speculative design, critical design, meta design etc. Examples related to HCI research include "Alternatives" [2], where a number of conceptual design proposals for information appliances were presented, critical design of electronic products by Dunne [1] and the Xerox PARC Artist-in-Residence program [4].

In this paper, we describe experimental design exploring the ever-present *expressions* of basic acts of information technology use: the reading and writing of information. We focus on the expressions of these acts almost to the point of completely neglecting their associated functionality. What we hope to gain is a better understanding of the *aesthetical* aspects of computational technology as material in the design of everyday things.

2 Slow Technology

When artists, designers, architects and engineers build an understanding of the properties of a material, they often study it by creating a structured collection of basic examples that explore different aspects and properties of the material. A basic understanding of the properties of, e.g., wood, paint, concrete, as materials for design, can perhaps only be achieved by working with them in practice. More systematic studies of the material are then used to map out the design space of possible expressions.

This notion of a structured investigation of a design material is the basic method of the work presented here. The purpose has not been to create applications, appliances or artworks, but to create a collection of examples that can support our understanding of aesthetical properties of computational technology as material for design. We have carried out our experiments by creating examples on basis of a design programme based on initial conjectures about the material. The experiences gained from this experimental work are then presented in terms of design guidelines, or design *leitmotifs*. In the work presented here, *Slow Technology* is the design programme; the acts of *reading and writing* using information technology is the part of the design space we are investigating; the *displays and devices*, including the *use scenarios*, constitute the examples; and finally the *design leitmotifs* present the experiences gained.

2.1 Framework

The basic premise of this work is that computational technology (computers) can be seen as design material, much in the same way as any other material we use to build everyday artefacts. Just like any other material, the computational material has specific properties that enable us to form certain expressions and to achieve certain functionality.

We have taken the exploration of temporal structures and different time-spans as a starting point for an investigation of the aesthetics of computational material. Basically, computers display the execution of programs, i.e., temporal structures. Thus, the expressions of computers have much to do with the expressions of temporal structures and correspondingly interaction design is concerned with how such temporal structures are expressed in human-computer interaction acts. In our experiments, we use the slow appearance of things to expose and amplify properties of temporal structures.

Slow Technology [3] is a "magnifying lens" through which we try to study the expressions of everyday computational things. Especially, we aim to work with time as an explicit design variable. Aesthetics, not functionality, is in focus. When we reflect on the expressions of computational things in use, they disappear as tools and their presence as temporal structures becomes amplified. The time perspective can then be changed and opened up for a technology that is slow in the sense that it is designed for reflective use. Slow Technology is technology that is slow in appearance, learning and understanding.

2.2 Focus on Expression

What does it mean to focus on the expressions of an artefact in use almost to the point of neglecting its functionality? Imagine using a pen but once you begin to write, you stop and reflect on how its shape affect the way you hold it and how you will form the letters. Then you think of where on the paper you will begin to write, how the ink will look when put on the paper, and so on. Here, the writing of a specific text is irrelevant. Still, it is clear that it is the expressions of a pen in use and nothing else that we reflect upon. To slow things down and reflect on the expression of an activity is also essential in traditions such as the Japanese Tea Ceremony.

3 The Expressions of Reading and Writing Information

The basic acts of using information technology can be characterised as reading and writing information: we write information as we type commands on the keyboards or draw figures with the mouse; we read information represented as, e.g., graphs and text on the screen.

A growing body of work has shown that there are many possibilities to broaden the spectrum of design strategies for human-computer interaction. Weisers visions of ubiquitous computing and calm technology (cf. [7]) were to some extent based on questioning the suitability of present forms of interaction. Within tangible media, several alternatives to present forms of information input and output based on the use of physical representations for digital information has been presented (cf. [6]). Both ubiquitous computing and tangible media have shown that human-computer interfaces can be created as a (natural) part of our everyday environments and that this integration might be an important step to putting the technology in the background rather than in the constant foreground of our attention.

Now, if our interest lies in finding out more about the properties of computers as material for the design of everyday things and environments, how can we build on these lines of work? One way is to keep questioning the basis for interaction design –how to support different forms of reading and writing information– but to do it from a different perspective that focus on the expressions of these acts and not on their associated functionality (cf. [1]). We have concentrated on the acts of reading and writing information in everyday life through everyday activities. We can, for instance, think about how we use thermostats to control heating, on/off switches for lamps to control lighting, or how we use doorbells to call for attention. These activities are very different from reading and writing texts using information technology, but they *are* elementary examples of situations where we interact with technology by reading and writing information.

To explore this, we created a number of devices to be used as a part of an everyday environment. The purpose was not to invent "new" technology, but to work with elementary modes of expression. We have aimed at exposing the aesthetics of computational material by amplifying and transcending acts of "reading" and "writing" information, such as: reading from public displays; communicating through devices, e.g., pressing doorbells; opening and closing closet doors, pulling out and pushing in drawers; entering and leaving a room, e.g., peering into, looking out, kicking the door open, slamming the door.

4 Displays and Devices

The displays and devices presented are designed to be slow in several different ways. Many of them are slow in the sense that they can not display rapidly changing information, but they are also slow in the sense that it takes time to use and understand them. They require people to reflect in order to make sense or to be “informative”. There is no reliable precision in measuring distance, light, movement, or in the calibration of scales in any of these “tools”. They are slow “instruments” for writing and reading information, instruments that require “artistic skill” to achieve precision. They invite to reflection on what, for instance, simple things like moving a metal cylinder between wooden blocks, pulling out drawers, reading patterns in pieces of fabric blowing in the wind, might mean in terms of reading and writing information. The individual displays and devices are described in their respective figure legends.

These displays and devices can be said to be practical examples of different interpretations of what various everyday acts might mean as acts of reading and writing information using information technology. If we think of the Fan House as a general-purpose display and compare it to the ordinary computer display, what happens with the act of reading information as we present information as movements on a surface instead of by changing the colours of pixels in a fixed matrix? Just like the Fan House with the substitution of pixels for moving layers of fabric, many of these examples bear on a relationship with existing interface components: the Chest of Drawers is related to the GUI desktop metaphor with its filing cabinet and folders; the Block Bench with GUI components such as the scrollbar and sliders; the Paper Recycler to information manipulation functionality such as the ability to cut and paste in a word processor; etc. At the same time, they have a strong resemblance to everyday objects made out of materials such as textile, wood, paper, etc. that are traditionally used in interior design.

Figure 1: Fan House
The Fan House is a 3x3-matrix wooden rack with a fan mounted in each cell, and layers of thin fabric are hanging in front. Each fan is individually controlled using pulse width modulation (PWM) from a microcontroller, which in turn is controlled from a PC. Combinations of different layers of fabric of various textures and colours, give a wide range of possible patterns of fabric in motion with fine structured variations.
Reading: as patterns of fabric in motion.
Writing: as patterns of information controlling nine fans.

Figure 2: Fabric Door
Fragments of fabric in different colours and textures are hanging in the ceiling, enclothing the entrance to a room. Each fragment is connected to an accelerometer which measures fabric movements as people pass through the door. A microcontroller registers how acceleration, velocity and tilt angle change over time, and forwards this information to a PC.
Reading: as a pattern of fabric in motion and indirectly as a pattern of accelerometer information.
Writing: walking through the fabric (cf. Japanese textile noren.)

Figure 3: Lamp Foot

The Lamp Foot is a floorlamp with the lampshade placed just above the floor. Inside, there are four small fans directed towards the downside perimeter of the lampshade, perpendicular to each other. Around and below the lampshade, there are dry autumn leaves laid out on the floor. Wind from the fans will transport the leaves out on the floor in different patterns. Each fan is individually controlled from a PC via a microcontroller.

Reading: as patterns of autumn leaves on the floor.

Writing: as patterns of information controlling the fans.

Figure 4: Paper Recycler

A matrix of electronic fans are mounted on a rack, covering the bottom of a cardboard box. Filled with paper fragments, the box and the fans create a display based on the movements of a large number of small pieces of paper in different colours, sizes, shapes and mass. As in the examples above, each fan is individually controlled from a PC. As the speed of the fans is modulated, different patterns of whirling paper can be seen in the wastebasket.
Reading: as patterns of different pieces of paper in motion.
Writing: as patterns controlling the fans.

Figure 5: Sail House
In each cell of a 3x3 matrix wooden rack we have placed paper sails on three wooden sticks, one for each column. Each mast may be used to turn the sails in a column in different directions; each sail can also be manipulated separately. A microcontroller is used to measure the resistance of nine light dependent resistors mounted behind each sail. The amount of light that each sail lets through is continuously measured and forwarded to a PC.
Reading: as patterns of papers sails set in different directions and indirectly as patterns of light intensities.
Writing: setting up different patterns of paper sails.

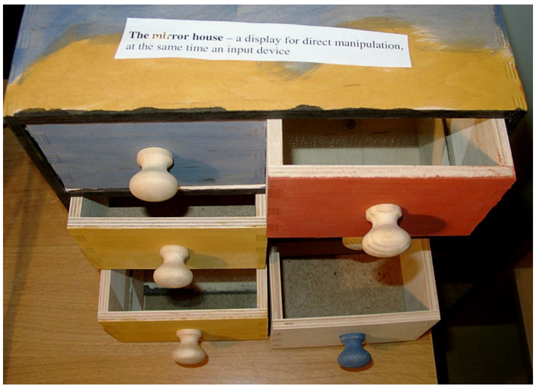

Figure 6: Chest of Drawers

A small wooden chest with six drawers has a mirror attached to the bottom of each drawer. The mirrors reflect light inside the drawer when opened. In the ceiling of each drawer there is a light dependent resistor for measuring the intensity of the reflected light. A microcontroller is used to measure the varying resistances, and the measurements are forwarded to a PC.
Reading: as a pattern of drawers pulled out to varying extents and indirectly as a pattern of light intensities.
Writing: pulling out and pushing in drawers.

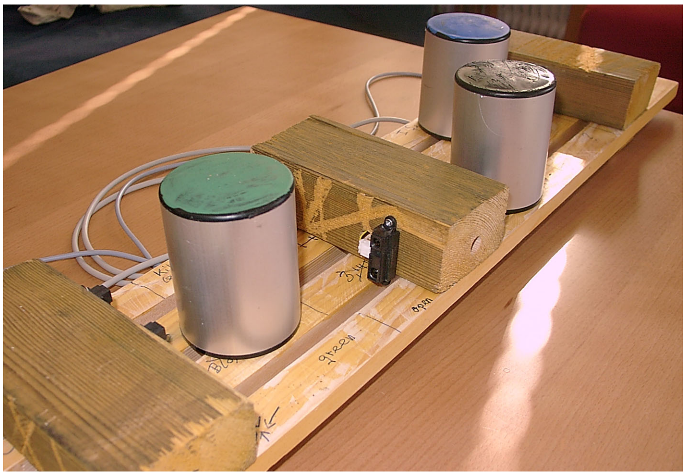

Figure 7: Block Bench
A small wooden bench with three tracks. There are four movable wooden blocks, with proximity sensors facing the tracks. Four metal cylinders are placed between the blocks as sliders. The Block Bench can represent four positions in three different scales. A microcontroller continuously reads the distances and forwards these measures to a PC.
Reading: directly as a pattern of blocks and sliders on the bench and indirectly as a pattern of distance information.
Writing: setting up different patterns of blocks and sliders on the bench.

Figure 8: Tray
A rectangular metal tray is hanging from the ceiling in four wires. Four stepper motors with gears are used to heighten or lower each wire in very fine steps so that the height and inclination of the tray can be precisely adjusted. Objects like marbles, nuts or even coffee cups that are placed on the tray creates patterns when sliding on the tray as the inclination is changed.
Reading: as pattern of moving things on the tray.
Writing: as patterns of information controlling four electrical stepper motors.

5 Use Scenarios

5.1 Simple Display Settings

The display settings described below concern the reading of information. Being parts of a designed interior, the displays will become familiar things over time. As we gradually learn to master the art of reading from these various displays, we will note information in the same manner as we note dust in the corner, or that someone has moved a particular flowerpot to the left in our living room.

History

The four fans of the Lamp Foot (fig. 3) can be made to represent four different sources of information or four aspects of some source of information. The pattern of light material, like dry autumn leaves that are spread out on the floor, will print the history of this information over a period of time.

Reports

Let the three columns of fabric in the Fan House (fig. 1) represent the weather at home, at some distant place, and the weather of the same time yesterday at home, respectively. Let the three rows represent temperature, wind and rainfall. Fabric of different colours and texture can be used to indicate the different kinds of information. In this configuration, the Fan House can be used to continuously deliver a weather report. Another possibility is to combine different kinds of information to create an overview display of, e.g., the energy consumption of a household.

Balance

The Tray (fig. 8) can be configured to display the balance between different processes. For example, we can make each of the four motors represent some source of information, e.g., the volume on stereos, television sets, or temperature measured indoors/outdoors, at home and at the office. The Tray will then show information about the balance between these different sources of information. If there is great imbalance between the different processes, an alarm will occur, as the objects on the tray will fall to the floor.

We can also use the Tray to create a display for the stressed out modern mother/father, who tries to achieve balance in life. For instance, we can let the four sources of information be the amount of time scheduled in the (electronic) time manager for work, for exercise, for spending time with the family, and with mother-in-law, respectively. In case the information sources are not hidden, the display can also be used to encourage other people to reflect upon someone's life situation.

5.2 Simple Communication Settings

Furniture in Use

You can display a part of your daily life by connecting the Chest of Drawers (fig. 6) to the Lamp Foot, thus writing the story of a piece of furniture in use in the form of patterns of e.g., autumn leaves on the floor.

To Enter a Room

The Fabric Door (fig. 2) can be used to display the manner in which people enter a room by means of patterns of moving fabric. The sensors in the Fabric Door will at the same time generate information that can be displayed in ways that mirror and communicate these patterns of moving fabric. For instance, one could set up the Fabric Door with displays like the Paper Recycler (fig. 4) and the Lamp Foot. In the first case one would see the movements of people scaled down to movements of paper in the Paper Recycler. In the second case one would see a history of people moving about in a room as a pattern of dry autumn leaves on the floor in another room.

To Use a Doorbell

We can replace the ordinary doorbell with a silent and subtle way of communicating by placing the Sail House (fig. 5) at the front door and connect it to the Fan House placed somewhere inside. When someone is at the door, he/she can present him-/herself by setting up a certain pattern in the Sail House. This doorbell needs explicit attention to when the fabric of the Fan House begins to move, as well as to how the fabric moves. A quick glance is enough to see that someone is at the door and a more careful inspection will reveal who it is.

5.3 Complex Settings

Connecting several of the displays in various ways open up for more complex settings. The Block Bench can be used to illustrate this. We may think of the Block Bench as giving us a collection of sliders for fine-tuning, browsing and mixing information. Due to the peculiar design of the Block Bench, the expressions of listening, watching and reflecting –activities that are involved in all manual fine-tuning, browsing and mixing– will be amplified as using the Block Bench is an art that takes a long time to master. This means that these complex settings will ask for even more reflective use than the simple settings given above.

Fine Tuning

We connect the sensors of the Fabric Door to the fans of the Fan House. Three sliders will be used to control sensitivity, mapping patterns between sensors and fans, and the browsing between different subsets of sensors. Now it is possible to use the Block Bench for fine-tuning the display of information from the Fabric Door through the Fan House. It is no meaning to look for exacts measures to remember for a later occasion, we have to “see” that it is “right”. In this setting we mix a specific expression of fine-tuning with expressions of reading information in the dynamics of moving fabric.

Browsing

We connect several sources of information, e.g., different sources of information from a weather station etc., to the Paper Recycler or the Fan House. The sliders can now be used to browse through information with respect to differently calibrated scales on the Block Bench. Since a precise handling of the sliders is a rather subtle matter, we introduce a notion of uncertainty. We have to check over and over again to learn what information we are viewing at a given moment. Successively we try to learn to read the patterns of the sliders, but expressions of uncertainty and learning will always be present. Here we mix the expressions of uncertain browsing with expressions of reading information in dynamic material like paper or fabric.

Mixing

We connect the Tray to four different sources of information –e.g., the Sail House, the Fabric Door, a weather station and the Chest of Drawers– where sliders on the Block Bench will represent sensitivity in connection with respect to each source. The sliders can then be used to mix information from these sources, and the Tray will display balance between them. The expression of mixing here will be that of intense listening, trying to understand the meaning of a mixture of information we are in the process of learning to read. Therefore, there will be a combination of the expression of curious listening with expressions of reading balance in the movements of items on a tray.

5.4 Extreme Settings

If we push the notion of ubiquitous computing [7] and the invisibility of computers (also in a phenomenological sense) to the extreme, we can imagine the following: As information is everywhere, we just have to define a display in order to read it. This idea implies that wherever there is expression, there is possible information.

Anything can be made into a display, since a display is just a place where we "read" information. We can, for instance fully integrate the displays and devices described here with the rest of the interior, e.g.: the Fan House becomes the place where you hang your towels, alternatively we place the fans behind the curtains of our living room; the Fabric Door becomes integrated with the wardrobe, clothes replacing the pieces of fabric sensing movements; the Chest of Drawers in the bedroom receives new expressions in use with light sensors, effectively becoming a device for "direct-manipulation" of information; the fans at the foot of a lamp controls the way dust will distribute on the floor in the hallway; the waste basket becomes a display, etc.

Everything we do can then be considered writing: we "write" information as we move around, touch things, speak, etc. Our environment will in return display different interpretations of this information, and everywhere we will be able to "read" information about various things such as what we and others have "written" through our actions. There will certainly be room and incitements for reflection upon these acts of reading and writing information using information technology, e.g.: the curtains moves as someone stands at the door; the TV changes colour depending on the weather outside – or was it the weather of yesterday?; the water tap in the kitchen does not work – did I forget to lock the car?; the dust on the floor is all in one corner – my fiancé is wearing a red dress today, or does it mean that I should pay the rent (I can never remember which corner is which)?

Here, everything is connected to everything else. Wherever there is expression, this expression is amplified as acts of reading and writing of information using technology. Will it matter what is connected to what, and what is not connected at all? The complex patterns of interactions between input and output, between what is an act of writing, where the information comes from, what controls the modulations of the information we are reading, etc., will hardly be possible to discover. The computer becomes invisible to the point that it no longer matters if it is actually there or not. Two interesting insights can be gained from this scenario. The first one is that we probably do not want the computer to be invisible, we just want it to lose its peculiar status as a design material that prevents it from becoming just another material we use for the design of everyday things. The second is that we do not want an information display to be too ambient, too integrated, but instead exposed in a way that makes its expression as an information display clear.

6 Design Leitmotifs

The work presented here is explorative and the ambition has been to uncover new design opportunities rather than to refine already, within interaction design, known ones. Thus, it is not plausible to give any detailed guidelines beyond the point of suggesting an outline for future work and along what lines a design practice might evolve. The guidelines, or *leitmotifs*, presented below represent the more general experiences we have gained while working with the design examples presented in this paper as well as projects preceding these [3, 5]. The experiences have been gained from both working with the design and implementation of the examples, as well as from occasions when people have tried them in real-world settings such as in office environments and at an art museum exhibition.

1. Composing in Time

Computational things are based on the execution of programs. One implication of this is that when working with such things, we work with temporal rather than spatial form. The aesthetics of computational material is clearly related to expressions as "time gestalt". If we want to uncover the intrinsic properties of computational material we have to put dynamics and behaviour over time in focus.

2. The Computer as a Display:

We can think of a computational thing as a display: as something displaying the execution of programs. Using this metaphor, we can also give a non-technical unified account of what a computational artefact is from a users point of view. According to this metaphor, the expressiveness of computational material is "contained" in the expressiveness of a display.

3. The Ubiquity of Information:

When we interpret everyday activities as acts of reading and writing information we can discover that there are potential "information displays" everywhere there is information. If we think about the way a person enters a room in terms of making an "imprint" that is there for others to "read" we uncover a design opportunity also for interaction design: just as the information is there for others to read, it can be used in an act of interacting with a computer. Correspondingly, digital information can be made available in the environment just as the imprint is available.

What is relevant here, is not that we can connect everything with everything else, but the new ways of thinking about what it is to interact with a computer that these scenarios can inspire and support. The notion of a computational thing as a "display" seems to limit what spatial appearances we can create. The notion of "ubiquitous information" and the extreme scenario described above, however, implies that these limitations are rather illusory.

4. Aesthetics:

When we want to find out more about the intrinsic expressions of computational technology as material for design, we sometimes have to disregard functionality. Instead of asking what the use of thing is, we can ask for what it expresses. As we disregard functionality, we often have to design for settings not typically associated with work. Within a work practice most instances of computer use will be defined by its use as tool.

This difference in what is considered valuable or interesting became evident when people used the displays and devices presented here in real-world settings. At the art museum exhibition, most people appreciated the installations and found that they opened up new perspectives on what human-computer interaction might be like. In the office setting, however, there were frequent complaints about the lack of clear functionality. Both reactions are plausible given what activities these two different kinds of environments are designed to support, and as interaction designers, we have to work with both kinds in order to broaden our understanding of interaction design.

If we do not try to hide the technology behind the smooth, nice and tidy surface that characterises most electronic products, we can expose the technology itself and encourage people to reflect upon its workings. Not focusing on the surface of the interface itself also forces us to consider the design as a whole – we do not just give the technology a certain interface, but form a coherent expression that is consistent throughout the design and not just on its surface.

7 Concluding Remarks

The expressiveness of computational technology as design material concerns ways of building temporal structures using a wide variety of spatial building blocks. Slow technology can then be thought of as a program for exposing such structures in various computational things and thus exposing basic aesthetical properties of the computational material building these things.

We will continue the experimental design work in the direction pointed out by these leitmotifs to gain more experience as a basis for further reflection on the aesthetics of computational design material. Both in the concentration on form as "time gestalt" and in working with a sort of "abstract" material we see connections with musical composition. We will try to follow this line of thought and in future experiments more consciously and systematically merge "design" and "composition" in the experimental design of computational things.

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FROM USE TO PRESENCE
ON THE EXPRESSIONS AND AESTHETICS OF EVERYDAY COMPUTATIONAL THINGS

lars hallnäs & johan redström

Abstract

Information technology is rapidly changing from being tools for the researcher or the business professional to becoming part of the building blocks we use to construct our everyday lives. With the coming ubiquity of computational things we have to consider what it means to design computational artefacts that eventually become a natural part of people's everyday life. We argue that this development urges us to consider what it means for something to be *present* in someone's life, in contrast to being just used for something.

"Use" and "presence" represents two perspectives on what a thing is. While "use" refers to a general description of a thing in terms of what it is used for, "presence" refers to existential definitions of a thing based on how we invite and accept it as a part of our lifeworld. If we ask for the use of a chair, we ask for the purpose with having a chair, what we use chairs for, etc. If we instead ask about the presence of a particular chair in someone's living room, we are not interested in what chairs in general, or even this particular chair, can be used for, but in the role and meaningfulness of this particular chair as present in this person's life.

Searching for a basis on which these existential definitions are formed, we argue that the *expressions* of things are central for accepting them as present in our lives. This places aesthetics in the centre of design. Aesthetics is not about the creative or artistic surface of these everyday computational artefacts, but about how their expressions form an identity that can make them meaningful building blocks in someone's lifeworld. We argue that aesthetics, as a logic of expressions, can provide a proper foundation for design for presence. We go on to discuss the expressiveness of computational things as depending both on time structures and space structures. Finally, an aesthetical leitmotif for the design of computational things –a leitmotif that may be used to guide a normative design philosophy, or a design style– is described.

Keywords: Ubiquitous computing, information appliances, design, aesthetics, phenomenology

1 Introduction

> Over the next twenty years computers will inhabit the most trivial things: clotheslabels (to track washing), coffee cups (to alert cleaning staff to moldy cups), lightswitches (to save energy if no one is in the room), and pencils (to digitize everything we draw). In such a world, we must dwell with computers, not just interact with them. *Weiser* [31, p. 3]

> The aesthetic potential of the narrative space centred on the consumer product has received surprisingly little attention from artists and writers and even less from designers. Few films or stories acknowledge how our lives and identities are intertwined with machines and artefacts, particularly everyday electronic products. Though we inhabit an environment of electronic gadgets and gizmos, little effort is turned towards exploring what this means. *Dunne* [5, p. 62]

Information technology is changing from only being tools for the researcher or the business professional to becoming part of our everyday lives. Part of this change is due to the rapid development of inexpensive embedded, wearable and mobile computing systems and the continuous miniaturization of components that allow us to create a vast range of novel computational artefacts at a reasonable cost. This technological development and its implications for how we both think about and design human-computer interaction have been the starting point for several lines of research in recent years such as ubiquitous computing [30, 32], tangible media [15] and augmented reality [34].

Here, we will take a step back and discuss some of the implications of this development. Our discussion will be centred on a perspective of increasing importance in technology development, namely *phenomenology* [cf. 27, 35]. We argue that the coming ubiquity of computational artefacts drives a shift from efficient *use* to meaningful *presence* of information technology. Our interpretation of this shift from use to presence comes mainly from working with various forms of novel human-computer interfaces [cf. 24, 25]. Having encountered problems such as how to evaluate a certain design, and describe what constitutes good design in these areas, we came to question the relevance of some of the basic assumptions in human-computer interaction. In what follows, we will try to discuss some of the problems that, to us, suggested that we might have to change perspectives when designing and evaluating everyday computational things.

The design and evaluation of an artefact are always done in relation to a definition of what the artefact is; what it is that we aim to design. In human-computer interaction, we usually think of the computer as a tool for achieving certain ends, such as creating a document or searching for information. We thus evaluate the usability of computational artefacts in relation to criteria such as efficiency, simplicity of use, and ease of learning, based on a relatively precise description of what they are used for. We may call descriptions of things along these lines *functional* descriptions based on a general notion of *use*. This is what we do when we ask what a house, or a hammer, is and answers with a description telling what houses and hammers in general are used for. These are descriptions of artefacts focused on the general objectives of use without any reference to a specific person that uses them in some specific situation.

We can also answer the question of what a thing is in a different way, as when we ask a friend about a certain piece of furniture in her home and she answers that it is the table she got from her late grand father. Clearly, it would be inappropriate to answer such a question with that it is a piece of furniture on which you can put this or that kind of object provided it does not weigh more than X kg. When we ask questions about this particular table, we do not ask for its general use, but about its existence in our friend's life, e.g., its role or place. When we learn what it is, we get an *existential* description of what this particular table is to our friend, a description based on the table's *presence* in her life. Unlike a description based on a general notion of use, this definition in terms of presence is related to a particular meaning given to a specific unique thing.

The notion of presence that concerns us here is not the mere physical existence of things in someone's surroundings, but rather the existence of things in our everyday life based on an act of acceptance; we give certain things a place in our lives as we turn to them and let them enter our life [cf. 3]. The presence of a certain phone means that it exists as someone's phone or the phone at someone's office or home, with a specific meaning as such. Thus, presence concerns the existence of things based on an existential definition of what they are.

Currently, human-computer interaction is dominated by references to functional descriptions of artefacts based on general notions of use, while references to existential descriptions based on presence is almost completely neglected. However, increased physical presence of computers in various environments, frequently governed by the notion of the invisible or disappearing computer, is gaining a growing interest in sub-fields of human-computer interaction such as ubiquitous computing. Frequently, computers becoming an integrated part of everyday life is taken to be something equal to embedding computational technology in various artefacts or in the walls of a building.

Clearly, this is not what was referred to as being “present” in someone’s life as described above. Even if we expand our notion of use and usability in interaction design to include new forms of interaction such as automatic sensing of user activities and context-aware applications, this is still a matter of “use” in the sense described above. If we want to understand what it means for an artefact to be part of someone’s everyday life –and eventually to design for this– we have to consider its presence beyond just being physically there.

The two different perspectives on artefacts here represented by the notions of use and presence, have very different implications when it comes to design and evaluation of artefacts. When computer systems change from being tools for specific use to everyday things present in our lives we have to change focus from design for *efficient* use to design for *meaningful* presence. What does this shift of focus really mean? What is the meaning of “usability” with respect to this change? What could be a proper foundation for the design and evaluation of computational things with respect to presence? In what sense does the meaning of interaction design change as we shift our focus from use to presence?

2 Presence

Information technology in the form of devices such as mobile phones, personal digital assistants (PDAs), personal computers, and information appliances, is increasingly used in everyday life. As information technology pervades everyday life, computational artefacts also become a part of our lives: we can say that we let some of these artefacts enter our *lifeworld*. As we take them for granted in our lifeworlds, they often become something more than just tools to be used to accomplish given tasks.

Consider for instance the following observation made by designers of Nokia phones:

> the mobile phone was first considered to be a serious tool for certain occupations, especially the military, and then an item for business purposes. After a while –around the early 1990s– it became a consumer product in countries like Finland, Sweden, and the UK. In this adaptation to consumers' lifestyles, the personalization of the mobile phone may play an important role: In constant use the mobile handset becomes a very personal object that intensifies the user's feeling of being inseparable from it." [29, p. 173].

That a phone becomes a personal object and not just a tool for communication suggest that this phone has become a part of someone's life; my phone will not just be any phone, but a unique thing that belongs to my lifeworld, just as my house is not just any house but this particular house of mine.

To say that a thing is part of our life is to say that there is proper place for it in our lifeworld, it becomes a part of our life through a process where we find or define a place for it. Many kinds of artefacts have well-defined places, or categories of places, that they are more or less designed to fit. We can also design with such places in mind, as when we create furniture for a kitchen or a living room. While kitchens and living rooms are physical places, furniture designed for these places also indicate ways for these things to enter into our everyday life.

Personal computers were designed to fit into an office environment and the activities taking place there. They were designed to be efficient tools in the hands of the professional – a role we are beginning to understand as our knowledge about usability and user interface design matures. Thus, our present practice of interaction design is directed to this setting. Obviously, everyday life is quite different from office work and therefore other "places", interfaces and appearances have to be explored in order to find a broader repertoire of strategies for creating human-centred technology.

The perhaps most influential example of an alternative scenario for human-computer interaction is *ubiquitous computing*, as described by Weiser and his colleagues at PARC some ten years ago [32]. Their main intention was to replace the personal computer and move the interaction with digital information out into the rich physical space we inhabit. Other approaches that address similar issues on how to integrate computational resources with the physical world and make the combination something meaningful, usable and enjoyable to live, work and play in, include *augmented reality* [34], *tangible user interfaces* [15] and *ambient media* [36].

Originally, the ubiquitous computing experiment used computer displays, in the sizes of boards, pads and tabs [30]. These displays all used graphical user interfaces and were quite similar to ordinary computer displays. Later in the development of ubiquitous computing, however, more radically different forms of information displays and interfaces were introduced. One new approach was the notion of *calm technology* [33]. Calm technology can, for instance, be technology that continuously presents information to us in the same non-obtrusive way as for instance an inner office window is a way of obtaining information about the activities outside. A central idea is the notion of an interface that moves between the foreground and the background of our attention [33]. This has also been one of the main ideas behind the design of ambient information displays [36]. Clearly, many of these new experiments are not concerned with new functionality; rather they are explorations of new forms of appearances of computers and of how we can design their presence in everyday life by means of placement, interaction design, context-aware and/or embedded technology, etc.

Often, the goal of these experiments is to make the computer "disappear". While making the computer literally invisible might be a step in the right direction, disappearance in the phenomenological sense is more complex. Invisible things are the ones taken for granted: we do not focus our attention on the hammer itself when we use it – we just use it. The hammer is not invisible, but it "disappears" as it is just a natural part of us, something that we do not attend to or reflect upon, as we nail something. Similarly I do not consciously use my feet to walk – I just walk. In fact, most things present we take for granted as natural parts of our life. If the door to my house suddenly is gone as I am about to leave for work in the morning, the absence of the door in a very explicit manner forces me to reflect upon something that I have taken for granted. When I install a new door, I will gradually accept this new thing as the door to my house and after a while this thing too will become a natural part of my life that I do not attend to or reflect upon.

In this manner, things appear and disappear as parts of our everyday lives. Most of the time the things present in our lives will just be there without us attending to their presence. But presence of things presupposes a process of acceptance. Things appear and we open or close the door to our lifeworld for them. To build a sound foundation for design, we have to understand these acts of acceptance with respect to some reasonable, and clear enough, understanding of the notion of what of everyday computational things are.

3 Design for Presence

Design is in a certain sense a question of instantiation: to design is always to design something that is given, e.g., a "chair", a "mobile phone", etc. Correspondingly, we evaluate the result according to a description or a definition of what that something given is. When we design for use, this means for example that the design and evaluation of a thing is done on the basis of some definition of what such a thing is and what it is used for. If we instead want to design and evaluate a design with regards to presence of designed things in our everyday life we are faced with the problem of relating design and evaluation to existential definitions of things, e.g., to their particular existence in someone's lifeworld. What does this mean in practice?

The intended object of a design act determines a collection of design variables describing what we intend to design and also roughly how. The design process is in an abstract sense the process of making these variables explicit and form concrete instances of them. An abstract form is implicitly given by the choice of variables, and the instantiations of these variables carry with them the specific material form. If it is about designing a chair we may think of variables like the legs, the arms, the back and the seat of a chair. Now, forming a concrete instance of a back of a chair of course also involves design. Thus, it is again a matter of making design variables explicit, etc.

At certain moments in the design process it seems as if this regression stops and we just form a concrete instance of a variable without making explicit what it is, i.e., there are no explicit variables describing what this something is, it is a pure atomic design form. The design process in this sense involves a series of choices: we choose variables for composite design forms; we choose atomic design form, etc. Reflecting on the resulting thing, it is natural to ask where these choices come from and what they are based on, if it is a good design or if a different series of choices could have resulted in something better. As we reflect on these matters we, at least implicitly, form a picture of a collection of design variables and a series of choices that builds the thing, i.e. we describe *a* design of the thing.

In interaction design for computer systems, use is traditionally in focus when determining design variables and their instantiation. We seek a solution that satisfies basic criteria for usability such as efficiency in use, low error rate and support for recovery from error, based on general knowledge about what to do and what not to do to meet these criteria [cf. 12, 20]. We aim to achieve maximum usability with respect to a general precise notion of use and our design is motivated by this ambition. Thus it is reasonable to think that we can set up user tests in order to value the usability of the design. Such a test does not necessarily examine the strength of the inner design-logic that builds the thing and perhaps a different explication of what its use is would result in a better evaluation. But still, given a well-defined notion of intended use the user test will relate design choices to usability. For instance, we can perform usability studies based on methods from experimental psychology to assess to what extent the different criteria are fulfilled in comparison to some other design. This enables us to discuss and compare different designs with respect to a general functional definition of the designed things.

If we instead turn to artefacts as they are defined in terms of their place and role in everyday life —an existential definition— the situation is quite different. There is no longer a well-defined general notion of use that will cover all these "different" definitions in sufficiently many non-trivial cases and so the notion of a user is consequently somewhat blurred. Given the difficulty of providing a proper definition of use in this context, it is even hard to say what a user test would be here. The notion of *a user* is in general a difficult notion [cf. 11], but here it is as if *the* user disappears into thin air leaving the artefact and its expression behind, open to be used in various ways. Consider, for instance, evaluating a doorknob [cf. 21]: some doorknobs are certainly things that are present in my life with expressions that can not be captured in any non-trivial way by a general notion of doorknob usability.

When thinking about the presence of things, we seem to face a situation where we cannot relate general design and general evaluation to the existential definition of a specific thing. An existential definition is based on an act of acceptance, i.e. we turn to a thing and give it a place in our lives. Behind the various manners in which things present themselves to us there is something, which remains invariant with respect to all the different possible existential definitions. When we design for presence we have to relate design and evaluation to some picture of this invariant "thing" that in some sense builds the things we define as we accept them to be present in our lives. Although this is a rather unfamiliar situation in human-computer interaction research, it is perhaps the basic perspective in art and design. In these areas, it is clear that we relate both design and evaluation to existential definitions of designed things. This is what we do when we picture what to design as we work on the design of a floor lamp. We clearly have a picture of something general, that may build meaningful things in several of our rooms, that can not in a simple fashion be reduced to something described in terms of the general use of a floor lamp. This is also what we do when we, as a basis for a richer experience, try to understand the inner logic of a painting or a musical composition. Here, the expressions of things become central.

3.1 Expressions

Our primary interest here is how computational things enter into our lifeworlds. To some extent this is something we actively do: we choose to have certain objects, such as a particular piece of furniture, a painting, or a mobile phone, around us. By giving things a place in our home we "invite" them into our lifeworld. But we do not actively decide to take them for granted as a part of our life: this is something that happens (or do not happen) over time. When we buy a new sofa, it is clearly visible to us and we note its presence hopefully feeling happy about our new sofa. Over time, however, the sofa will gradually "disappear" to us as we increasingly take it for granted. Eventually, there are objects in our near surroundings that we do not "see" until they are gone or when we suddenly discover that something has changed. While this gradual disappearance is characteristic of presence, what is central here are the first encounters with an object, i.e. we focus on what happens when it is introduced to us and an act of acceptance can begin.

This first invitation clearly has something to do with appearance: what an object is like as it makes its appearance in our life, when it presents itself to us. A thing always presents itself through its expressions. The expressions of a thing are its pure appearances as we disregard –or "bracket"– functional and existential definitions. It is what defines the thing as an abstract "expressional", a bearer of the properties of expressions that are invariant across the many different existential definitions, i.e. an *expression-identity*. Similar to how we may think of a thing as an *appliance* – a thing designed to perform certain functions – we may think of the bearer of this expression-identity as an "expressional" – a thing that is designed to be the bearer of a certain expression[1].

Appliances and "expressionals" refer to two different perspectives on what it is that we design. When we design everyday things such as wristwatches, cars and furniture we in general consider both. As we consider the expression-identity of things – the "expressionals" – we, phenomenologically speaking, put the general notion of well-defined explicit use and of a well-defined user within brackets. Consider, for instance, the expression-identity of a chair: we use the chair to sit down and rest, to sit down and watch a movie, to sit down and work, etc. That people sit down in the chair belongs to the expression of the chair, but the users disappear as we refrain from referring to why they sit down and what they are doing sitting in the chair. If we think of a bicycle and what characterizes its expression, we do not think of it in terms of that it is used by Mary to go to the beach, or by a child that is learning how to ride a bike. Despite the fact that it takes a person to ride the bike, we just focus on the bicycle itself when we think of it. We may also think of a phone not in terms of an interaction model based on the notion of phoning, but instead in terms of an artefact with certain expressions, made from a certain kind of (technical) material,

1. We use the construction "expressional" along the same lines as the established word "confessional" – "a small enclosed stall in which a priest hears confessions", i.e. as a thing designed to be a room for confessions.

that people use to build their everyday life. If we think about a phone in this way, we disregard, or "bracket", the user and instead turn to the expressions as a foundation for existential definitions.

When we let things into our lifeworld and they receive a place in our life, they become meaningful to us. We can say that this act of acceptance is in a certain sense a matter of relating expression to meaning, or to give meaning to expressions. Sometimes this is an explicit act, as in gift-giving and rituals (consider for instance how the wedding ring is given its place in the ceremony), but more often this process of becoming meaningful happens gradually over time. However, in both cases the result is that things become bearer of meaningfulness through its expressiveness. It is this expressiveness and meaningfulness that is basic to design for presence.

We can also think of expressions as something characteristic to a thing, as it has entered into our lifeworld. For instance, when we look into the home of another person, the things we find tell something about this person beyond the functionality of these artefacts. In many cases, the precise meanings of a particular object to this person is not clear to us, but still they express something and as we see this, we can ask for what a particular thing is in terms of its presence. For instance, we might find an object of seemingly little value placed in a way that suggest that it is very precious to its owner and therefore ask for what it is (cf. [3]). Correspondingly, the owner of this home expresses herself with these things. Consider a musical instrument as an example: when we first see it, we might reflect upon its construction, its shape and proportions, whether it is new or old, made by a craftsman or a machine, etc. Then we might perceive it in its context; this musician's instrument does not just lie there as one of many examples of what a music instrument is, it tells us something about the musician and the instrument's place in her life. If I play the violin this thing helps me to express the meaning music has in my life to myself and other people. It is this type of musical expressiveness and meaningfulness that is in focus when designing a violin and not usability in a more narrow sense. The notions of musical expressiveness and meaningfulness guide the design, they are the basic leitmotifs for the design process.

When I ask for what a thing is and what it expresses, I ask for the place it has in my life. This new usability or usefulness is not about instrumental functionality, but about the design and construction of things that can become a meaningful part of the environment and of our lives. Thus, we have to design these computational everyday things in ways that makes it possible for people to give them meaning, to give them a place in their lives, in various ways. This is quite different from creating technology that is just easy to use; it might even be the case that the artefacts that become most meaningful are not at all the ones that are easy to use.

We can relate this to Borgmann's notion of focal things as it is used in design practice: "Focal things /... / are things that ask for attention and involvement: they desire a practice that cannot be characterized by consumption but by engagement". [28, p. 41] [cf. also 1, 2]. Focal things are not designed to disappear; rather, they act as engaging centres in human practices. A violin, as a musical instrument in the hands of a musician, is a focal thing, while a Stradivarius placed in a museum, is not [1].

The concept of an "expressional" can be used as a basis for the design and evaluation of computational things in regards to presence, and also serve as a complement to use as a basis for interaction design. Thus, we design bearers of expressions as we design for presence, expressions that invite to acts of acceptance. However, we also need methods for comparing different designs with respect to a given type of "expressionals", methods for the systematic reflection and critique of expression-designs of computational things. This is where aesthetics becomes central.

3.2 Aesthetics

A narrow definition of use can give us external criteria for empirical user tests. Evaluations of the expression-logic of artefacts forces us to focus on the internal structure that builds the expression. When evaluating design with focus on existential definitions, we can look for what is invariant in regards to the expressions of the artefact, the identity of the object. We are not evaluating the thing as it is defined in an existential definition, but its expression-identity as a foundation for such definitions.

To try to understand and explain the logic of this expression-identity seems to be a reasonable basis for evaluation. It is a possible foundation for an abstract critical evaluation of the design of artefacts. Evaluation then turns into aesthetics: to understand the logic of an expression on the basis of understanding the material that builds the expression.

We may think of an expression as the presentation of a structure in a given space of design variables. The design itself can be seen as an act or a process that defines the expression. To understand and describe such phenomena is in a certain sense a matter of logic. Logic in a broad sense deals with formal matters, the general forms of certain specific things such as the forms of correct arguments. Form can be seen as the way in which matter builds a thing. Aesthetics, as we understand it, is concerned with how material builds expressive things, i.e., a logic of "expressionals".

It follows that good design from an aesthetical point of view basically is a logical question, not primarily a question of psychology, ethnography, sociology etc. It is a basic axiom here that it is through the force of its inner logic, its consistent appearance, that a thing receives depth in its expression and thus its strength to act as a placeholder for meaning. Behind each expressive thing present in our lives there is an "expressional" with a strong form. From an aesthetical point of view this is also what is the foundation for the character we ascribe to things (cf. [16] for a discussion about the character of computational things.)

To design with aesthetics in focus means to concentrate on appearance as constituting the essence of things, how a thing manifests itself in a world of expressions [cf. 37]. This is much easier to acknowledge in the areas of art and music critique. Consider for instance a valuation of the 2nd Brandenburger concerto by Bach: what is it that such a valuation would refer to? Probably not the precise notational text of the Bärenreiter edition no X nor a particular performance by Concentus Musicus. It would be something much more abstract, a specific expression that is invariant with respect to all various performances, i.e., the musical idea as it is expressed through notational text. In the same manner we will have to trace the idea of computational things as we try to understand the logic of their expression-identities.

Consider a typical graphical user interface (GUI) on a desktop computer. Components of the interface can be seen both as constituents of an interaction model and as constituents of an expression structure. It is the expressions of these components that convey the meaning they have in the interaction model and it is also the expressions that talk to me as I form an existential definition of the GUI in my daily work with the machine. To make sense of the interface structure means in a certain sense to describe and evaluate its expressiveness. This is comparable with analysing the logical form of an argument and evaluating its logical correctness.

We have yet no stable tradition of aesthetics within the domain of human-computer interaction that, in a systematic way, will help us reflect upon the expressions of computational things in this manner. However, as computational artefacts become more and more important in our lives, their importance as existentially defined objects will increase. This, in turn, will force us to begin to reflect on the aesthetics of computational artefacts. As a basis, we can use critical design, experimental design and similar approaches [cf. 5, 8, 9, 13].

Over time, these reflections will help the human-computer interaction research community form a tradition of aesthetics to complement the experimental tradition of usability studies.

4 The Expression-Identity of Computational Things

To understand the expressions of computational things, we have to search for intrinsic properties of their expression-identities, i.e. basic properties of computational "expressionals". In, for instance, graphical design and many areas of industrial design, form giving often means to design the exterior of an object. This is reasonable when the object is sufficiently static and when its internal workings do not contribute to the overall expression. If we think about the material that forms the expressions of computational things, it is clear that it is a combination of computations and interaction surfaces. Clearly, "aesthetical design" of computational things is not to give a computer a new and more colourful shell [cf. 4].

We may say that the expression-identity of computational artefacts is based on a combination of time structures (computation) and space structures (manipulation and display of results). Computational expressions have many similarities with musical expressions, as both concern temporal rather then spatial structures. Therefore, a proper aesthetics of computational things concern "time gestalt". However, interaction design also depends on spatial manifestations of the results of computations for various forms of input. We use displays, keyboards and other instruments to control computational processes and to see the results. Therefore, the expression-identity of a computational thing is based on both temporal structures and spatial manifestations.

Design for presence also requires a different perspective on what timespans we are designing for. The processes we design for in human-computer interaction often take place over hours, minutes or even seconds. When thinking about the interaction with computers in terms of dwelling, the time-spans in focus are much longer, e.g., days, weeks or even years. Of course, these long time-spans are considered in present interaction design as well as many systems are going to be used for quite a long time in an organisation, but the issue here is what we focus on when designing [cf. 17, p. xxxii]. Considering the point made by Weiser quoted in the introduction, we might say that while interaction is supposed to be fast, dwelling is not.

To design computational "expressionals", we can use design *leitmotifs* that support reflection upon the interplay between temporal and spatial structures. One such leitmotif is to think of the computational artefact as a display.

4.1 An Aesthetical Leitmotif: Computational Artefacts as Displays

As a basis for the design of an artefact, we always have some picture or idea of what kind of thing it is. Such a picture leads our thoughts in certain directions and can thus function as a key notion in a normative design philosophy; the picture helps us focus on certain aspects of the given class of things even if it, as a description, is highly incomplete. We have argued that a focus on the expression-identity of things seems to be reasonable when designing for presence, i.e., to acknowledge aesthetics as a basis for design. What sort of pictures could help us to focus on the expression-identity of computational everyday artefacts?

One such approach could be to consider the computational artefact as a thing displaying the execution of programs. A computational thing in this sense is not necessarily an electronic device; clocks, mechanical pianos etc. are also examples of such computational things. The expression of a computational thing depends on the execution of programs. Interacting with computational things means that we give values to program variables and initiate execution of programs in various manners. Time is a central form element for a computational thing in the same sense as time is a central form element in music. The picture of a computational thing as something displaying the execution of programs leads us to focus on expressiveness where time is a central form element. To open up for existential definitions of a computational thing, we can ask questions such as:

i) In what way and in what sense does it express the execution of a program?

ii) What determines what to be displayed?

iii) What initiates the execution of programs?

iv) What defines the given programs?

As we acknowledge a computational thing to be present in our daily life, we of course use it to do various things: we phone our friends, we remind ourselves of things to do, we listen to music, etc. To focus on expressiveness in design does not mean that we forget all about the use of computational things – it means that usability becomes subordinated to expressiveness when designing according to this leitmotif. A computational thing is a thing displaying the execution of programs: an "expressional" more than an appliance. We can use it to do different things, but its general definition is not given in terms of use.

Consider asking these questions about a phone in order to get a new "picture" of what a phone is. Is not the old picture very much a matter of how a phone looks as it is used, i.e. a matter of expression, as when we mimic using a phone by pointing the thumb to the ear and the little finger to the mouth? To take the traditional stationary phone as a starting point, rather limits the design space than open up for new perspectives. Instead, we could try to consider different types of display expressions by setting up collections of design variables as answers to the questions (i) - (iv). In this way, we define what a phone could be as a computational thing. The better we resist retreating to the old notion of a phone, the better chance we have of finding a new and useful design space. The notion of a computational thing as a thing displaying the execution of programs could help us here to focus on the phone as a more general class of expressions where time is a central parameter.

Assume that we will design a digital doorbell. A doorbell is something we use to call the attention of people inside as we stand outside in front of a door, to notify that someone is at the door. There is nothing in this description that refers to the expression of a doorbell. We can also describe a computational doorbell as a thing that displays the execution of a certain program everywhere inside of a compartment or a house as it is initiated outside a given door. This is a distinction between describing the notion of a doorbell in terms of use and describing what thing a computational doorbell is, in terms of its expression. In the first case, we will probably consider what it means to call the attention of people. In the second case, we will consider what it could mean to display the execution of a program everywhere in a house.

In contrast to the expressions of an artefact, its usability concerns the more abstract notion of use, i.e., the use of it. It is at this point that the definition of what a thing is enters the scene. We could design our doorbell on the basis of a rather precise definition of use, but such a definition would restrict the design space concerning the expressions of doorbells and it would rest on several assumptions concerning the forms of the existential definitions we implicitly, or explicitly, make as we acknowledge the presence of the doorbell in our daily life. If we, on the other hand, start with a general description of what thing a computational doorbell is in terms of its expression we may open up the design space and also make less assumptions on the forms of existential definitions to come.

5 Concluding Remarks

We have argued that the use of new computational things in everyday life, implies a shift from efficient use to meaningful presence. Many of these new computational artefacts will be defined by their intended use, e.g., the way information appliances are defined by the task or situation they are supposed to be used in [18, 22]. However, some of them will also be a part of someone's life in a more profound sense than as tools to bring forth when needed; the artefacts that surround us are more than components of a continuously available toolbox, they are present in our lifeworlds as parts of who we are, how we live and how we express ourselves.

Presence, as we understand it here, concerns the existence of things on the basis of an existential definition of what they are. We have described the presence of an artefact in terms of how it expresses itself as we encounter it in our everyday life. Then we can think of artefacts as "expressionals", artefacts as bearers of expressions rather than functions.

There is an immediate connection between the expression of a thing and various concrete forms of using it. This is related to the concept of affordances [cf. 7, 10]. Affordances also concern the meaningfulness of objects in relation to an agent but an important difference is that while these existential definitions of objects are made in terms of being present in someone's lifeworld, affordances are defined from an ecological point of view.

The perspective on artefacts as expressing something, rather than as being specifically used for something, places aesthetics in the centre of design. Aesthetics is not about the creative or artistic surface of these everyday computational artefacts, but about how their expressions form an identity that can make them meaningful building blocks in someone's lifeworld. Then aesthetics, as a logic of "expressionals", gives a methodological context for the "expressional" foundations of existential definitions of computational things.

When we focus on aesthetics one can get the feeling that we completely leave issues of truth and falsity, of good and bad aside. This is not at all the case. Aesthetics in focus means that we focus on expressions as a leitmotif for our road to understanding, not that we focus on the expression of things as static isolated items. Note the close connections between aesthetics on the one hand and epistemology and ethics on the other. Beauty and simplicity are often used as strong criteria for the correct path to deep theorems and good theories in areas such as mathematics and physics [cf. 26]. If I design a glass bottle, I ought to know that it partly broken can occur as a weapon in a fight and that this is part of the expression of a glass bottle. An existential definition of a thing means that I take care of how I concretely use the thing; I declare a position with respect to the expression of the given thing. When I place a stone in my garden as a decoration I implicitly declare that this is not a stone to crash windows with — when some younger person perhaps do just this, then this might be a reaction to my definition of what the stone is. All this leaves the designer in a classical existential situation with respect to her/his responsibility.

The two ways of describing and defining an artefact –in terms of use or presence– are complementary perspectives. Consider how we evaluate a piece of furniture both in regards to functionality and expressions: when we buy a sofa, we do not only consider whether it is in principle comfortable to sit in, we also ask ourselves whether its materials, design etc. will fit into the rest of the environment in the way we want. We both consider its practical functionality as a sofa and its prospective expressions as a sofa placed there in our living room. This is also acknowledged in many forms of design for everyday life, such as in architecture, interior design, furniture and clothing design [cf. 19, 23]. In the case of interaction design of computational artefacts, things seem to be different. Certainly, there is a very strong tradition of experimental psychology, but there is no corresponding tradition of aesthetics in relation to the existential definitions of a thing in human-computer interaction design [cf. 5].

Thinking in terms of presence opens up new design spaces. It has been argued that mature technology becomes transparent to its users. The ideas presented here point to a situation where the computer loses its unique position, and computational technology simply becomes one out of the many different materials we use to build everyday life. Of course, it will be a material with special properties, such as having form based on both temporal and spatial structures, but from an existential point of view, we will think of it as just another material: everyday computational things will be as familiar as everyday wooden things, everyday plastic things, etc. Eventually, they will be just "things" present in our lives, made out of materials we do not necessarily think about. Then, the computer has disappeared.

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