PLAYING WITH CONTEXT

Maria Håkansson
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Playing with Context
Explicit and Implicit Interaction in Mobile Media Applications

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Abstract

This thesis contributes with insights into how aspects of the surrounding physical and social context can be exploited in the design of mobile media applications for playful use. In this work, context refers to aspects of the immediate surroundings – outside of the device – that can be identified and measured by sensors; for instance environmental aspects like sound, and social aspects like co-located people. Two extensive case studies explore the interplay between users, mobile media, and aspects of context in different ways, and how it can invite playful use. The first case study, Context Photography, uses sensor-based information about the immediate physical surroundings to affect images in real time in a novel digital camera application for everyday creativity. The second, Push!Music, makes it possible to share music both manually and autonomously between co-located people, based on so-called media context, for spontaneous music sharing.

The insights gained from the designs, prototypes, and user studies, point at the value of combining explicit and implicit interaction – essentially, the expected and unexpected – to open for playful use. The explicit interaction encouraged users to be active, exploratory, and creative. The implicit interaction let users embrace and exploit dynamic qualities of the surroundings, contributing to making the systems fun, exciting, magical, ‘live’, and real. This combination was facilitated through our approach to context, where sensor-based information was mostly open in use and interpretation, ambiguous, visible, and possible to override for users, and through giving the systems a degree of agency and autonomy. A key insight is that the combination of explicit and implicit interaction allowed both control and a sense of magic in the interaction with the mobile media applications, which together seems to encourage play and playfulness.
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Part 1

Playing with Context:
Explicit and Implicit Interaction in
Mobile Media Applications
Chapter 1

Introduction

Play is an important part of life (Huizinga, 1955). It includes a wide range of exploratory, engaging, reflective, and creative activities that can happen at any time and anywhere. The research presented in this thesis explores how play and playfulness can be designed for and encouraged in the domain of mobile media applications on mobile phones. The mobile phone is a promising platform on which to explore different kinds of play because of its pervasiveness and computational power. What were until recently advanced technologies investigated in fields like ubiquitous computing and human-computer interaction are now standard components in mobile phones, where a variety of sensors, media players, full-colour screens, gigabytes of memory, together with wireless networking and Internet access, offer interesting unexplored opportunities for design. Using sensors, a mobile phone can for instance keep track of where it is located, its physical orientation, who is around, if it is moving, and much more. Such features could essentially make the interaction with a phone ‘wider’ by taking in aspects of the world outside of the device, which in turn could allow for new user experiences and practices. But how could they allow and encourage play?

In particular, this thesis explores how aspects of the surrounding physical and social context can be exploited in the design of mobile media applications for playful use. Aspects of context refer in this work to aspects of the immediate surroundings – outside of the device – that can be identified and measured by sensors; for instance environmental aspects like sound, and social aspects like co-located people. In doing this, this thesis explores the interplay between users, mobile media, and aspects of the surrounding physical and social context, and how it can open for new playful experiences. As proposed and argued here, such aspects can come to be a rich resource in the design and use of playful mobile media applications, where they can make new dimensions and interaction possible. This thesis provides new insights based on two extensive case studies involving the design of two prototype applications and the studies of them with users in real life.

Aim and Contributions

The aim of this thesis is to gain insights into how aspects of the surrounding physical and social context can be exploited in mobile media applications for playful use, through the design of prototypes and studies with users. As one approach to explore how to design for play, sensor-based information about the surroundings is used not only to give agency and autonomy to users, but
also to the applications, in order to promote spontaneity and unexpectedness. The design space in this work therefore consists of mobile media, play, aspects of context that are possible to sense with sensors, and agency and autonomy. The two case studies explore the design space in different ways, and they are briefly introduced below, before the main contributions of the thesis are presented.

The first case study of Context Photography explores how sensor-based information about the environment can be used as a resource for everyday creativity in digital photography. Aspects of the surrounding environment are sensed and mapped to visual effects that affect pictures in real-time, as they are taken. Using the Context Camera, which is the prototype application running on camera phones, users can let sound and movement influence the visual outcomes of still images. The Context Camera has been used in two workshops with users during the design process, and in an exploratory six-week study with amateur photographers. Our use of sensor-based information both gave the user room for playful and creative exploration as well as providing the camera with a degree of agency and autonomy. This allowed a combination of explicit and implicit interaction with the camera, which users experienced as challenging but at the same time also exciting, ‘real’, and spontaneous.

The second case study of Push!Music explores how co-located connected users together with a so-called ‘media context’ can be used to facilitate music sharing. In technical terms, Push!Music is an ad hoc peer-to-peer mobile music sharing and recommender system. In this case, co-located connected users might include both acquainted and unacquainted people, and the media context refers to the context in which songs (from a playlist) are listened to over time: which nearby songs are played, how are they rated, if they are shared with other people, etc. The media context is used by so-called ‘media agents’ – software agents that represent each song in the system. The Push!Music prototype system allows two ways of sharing music wirelessly between mobile devices: the first lets users manually send songs to other users, and the second allows songs (via media agents) to be autonomously copied between devices based on similar accumulated media contexts. The application was tested in two consecutive studies with users. First in a two-week study involving a group of friends, and later in a three-week study with a mix of ‘friends and strangers’. The findings revealed that although the system was technically straightforward, it was not equally straightforward from a social perspective. Users preferred to be active with friends – which involved playful sharing such as sending songs as pranks and in-jokes – and mostly passive with ‘strangers’. This implied that they hoped for songs to autonomously send themselves, as this required no effort, but generated excitement and curiosity, and was looked upon as a more ‘socially acceptable’ way to share songs between unacquainted users.

Based on the two mentioned case studies, this thesis provides three interrelated research contributions: the two prototypes, the empirical results from the studies with users, and collected design insights based on the designs and the studies.
The two prototypes — the Context Camera and Push!Music — are embodiments of design ideas, proof of concepts, and can act as inspiration for further exploration. They have been thoroughly designed in an iterative design process respectively, and have been documented in detail as well as demonstrated to the research communities of ubiquitous computing (ubicomp), human-computer interaction (HCI), and computer supported cooperative work (CSCW); industry; and the media. In themselves, they illustrate two ways of how different aspects of context can be exploited to allow new user experiences and practices in mobile media applications for playful use.

The empirical results from the studies entail knowledge and implications for design that go beyond the topic of this thesis, and are relevant to the ubicomp, HCI, and CSCW communities. For instance, the study of the Context Camera brings up considerations that could be relevant to other researchers who are designing technology for creative purposes, and the studies of Push!Music provide valuable accounts of mobile sharing, which could help understanding sharing practices in other domains.

The collected design insights are based on the two case studies in this thesis, and they describe:

1. the use of aspects of the physical and social context in the two mobile media applications;
2. how it gave the systems some degree of autonomy and agency; and
3. how this enabled a combination of explicit and implicit interaction with the prototypes and with mobile media.

Overall, for users, our designs resulted in a combination of the expected and unexpected, which in turn proved to be important with regards to encouraging and experiencing play.

Thesis Outline

This thesis encompasses two parts: an introduction, followed by a collection of four research papers; where each paper contributes to the collected results presented in the introduction. The first part has so far introduced the aim of the thesis and a brief overview of its contributions. It continues next with a background to this research, a chapter defining the design space, a chapter about the overall method, a chapter presenting the two case studies, a discussion of the contributions, conclusions, and finally a brief summary of the included papers along with a note on the division of work and in particular my contribution. The second part of the thesis contains four research papers, which all have been accepted to and presented at peer-reviewed conferences.
Chapter 2

Background

This chapter provides a background to the work presented in the thesis, which is influenced by and related to several overlapping academic fields, including HCI, ubicomp, CSCW, artificial intelligence (AI), and mobile HCI.

It begins with a brief theoretical section about the notion of play according to Huizinga (1955), which has been used in this thesis to look at the two case studies in terms of play. It provides a strong argument for the importance of play in life, and reminds us that we are inherently playful creatures. The chapter continues with a section about doing computing out in the physical world, which is the central theme in the field of ubicomp, and the technological domain of this thesis. Thereafter follows an overview of leisure and the design of information technology (IT), which both argues for the importance of addressing leisure in technology use, and illustrates how designing for leisure raises new challenges for design. The next section presents a number of leisure applications from both research and industry that illustrate different use of ubicomp and sensor technology. The final section draws attention to how systems can be given active roles – with agency and autonomy – in interaction or by influencing expected outcomes, and as a consequence open up possibilities for new experiences.

Homo Ludens

Dutch historian and cultural theorist Johan Huizinga introduced the notion of Homo Ludens, meaning ‘Man the Player’, in the 1930’s to bring to light the significant role of play in life (Huizinga, 1955). According to Huizinga, play cannot be explained using rational, logical or biological terms. Play is irrational and yet an inherently important part of human nature and culture, engaging both children and adults. Play ‘lies outside the reasonableness of practical life’ and ‘has nothing to do with necessity or utility, duty or truth’ (Huizinga, 1955, p. 158). Play is never a task and can never be forced. Therefore, play is not work, but according to Huizinga it is not leisure as in being passive and letting time pass either – play engages and enchants, which makes it an enjoyable and meaningful activity.

Huizinga argues that play is free, spontaneous and careless, and to observe ‘true’ play we can turn to children to see how they engage in it. Play is not ‘ordinary’ or ‘real’ life. When playing, the player ‘steps out’ of his or her ordinary life into a ‘temporary sphere’ that has a nature of its own with rules and structures. The rules are important and ‘determine what “holds” in the temporary world circumscribed by play’ (Huizinga, 1955, p. 11). The player might be intensely absorbed and enchanted by this temporary world, but is
still conscious of the fact that the world is pretended. An example is dressing up and taking on the role of another character: the person knows it is not for real, but has to play according to the ‘rules’ to not spoil the fun of the experience. Pretending requires in turn room for image- and meaning making and imagination. Play is further separate from ‘ordinary’ life both when it comes to locality and duration: it is “played out” within certain limits of time and place. It contains its own course and meaning. Play begins, and then at a certain moment it is “over”. (Huizinga, 1955, p. 9).

Ordinary life can at any time make itself known, interrupt and disenchant the player(s) in the temporary sphere. Play happens spontaneously, cannot be forced, and is voluntary. Huizinga meant that being engaged in play with others can create a strong social cohesion, an ‘air of secrecy’ and a feeling of sharing something important.

To be engaged in different kinds of art practices can also definitely involve play, but Huizinga (1955) claimed that there are stronger elements of play in music, dance, and poetry, as opposed to in the plastic arts (sculpture, architecture, painting, etc). A reason why plastic arts involve less opportunities for play could be that once a piece is finished, it is static and no longer performed, and thus does not invite viewers to make it their own to the same extent. Moreover, as soon as a piece of art is created for something – like in most cases of architecture – then it automatically loses its elements of play.

According to Huizinga, we should thus also be seen as playful creatures, where play is a necessary part of life. Play can however take many varying forms and must not only be thought of as games. Why is the notion of play interesting to bring up here? As an increasing number of researchers in HCI, CSCW, and ubicomp have acknowledged during the last decade, technology offers not only vast opportunities to support work activities, but also leisure activities and play. With ubicomp technology, which we will continue with in a moment, new opportunities to design for play arise also in the physical world.

Play in Relation to Games

Although this thesis is about play and not about games, it is useful to briefly look at the relation between them. French philosopher and social theorist Caillois criticised Huizinga’s theory of play (Huizinga, 1955), which he argued was too narrow with respect to games, and he therefore called for a broader view on play that included some types of games (Caillois, 1961). Similar to Huizinga, Caillois defined play as an activity that is voluntary; separate from the ordinary world in terms of time and space; uncertain where much is being left to the player’s initiative; unproductive; governed by rules, and based on make-believe. However, there were in particular four classes of games that he argued belong to play as well, and Caillois’ extended notion of play therefore encompasses these four: agon, alea, mimicry, and ilinx. In brief, agon games are based on competition or conflict as in football; alea games involve chance as in roulette or lottery; mimicry involves make-believe and playing a character; and finally, ilinx games are activities that
are based on dizziness and disorder as in roller coasters (Caillois, 1961; Walther, 2003).

Caillois’ broader notion of play illustrates that it is rather difficult to draw a clear line between play and games. Walther (2003) does however provide the following helpful distinction between play and games:

‘Play is an open-ended territory in which make-believe and world-building are crucial factors. Games are confined areas that challenge the interpretation and optimizing of rules and tactics – not to mention time and space.’ (Walther, 2003, p. 1)

Based on the work of Huizinga and Caillois, among others, Walther acknowledges that although play and games share several characteristics, such as they are both anchored in spatial and temporal settings, embedded in culture, and require a certain mood, they differ in level of complexity. Walther further points out that gaming is something that takes place on a higher level, structurally and temporally, compared to play. While play constantly needs to be negotiated by the player in order to ‘hold’, games rely upon ‘rule-binding structures’ that prevent them from running off target (Walther, 2003). However, according to Walther, play and games do not exclude each other: in fact, to play certain games (e.g. first-person shooter games), the player might initially need to get into a ‘play mood’ and a ‘play mode’ where he or she for instance takes on a character, before the player can emerge in the ‘game mode’ of playing the game itself.

As Rao (2008) acknowledges below, it also becomes difficult to draw a clear line between games and play, and what they encompass, when new technologies provide for new places and opportunities to engage in such activities:

‘the rise of hybrid products that blur the distinction between everyday reality and play space, and the increasing importance of “playfulness” or “playful mood” in domains other than game design, challenge the established notions of “games” and “play”, forcing game researchers to look for unconventional, larger perspectives.’ (Rao, 2008, p. 8)

Rao brings up Facebook¹, a popular social networking site, as an example of a new place that invites playfulness. She argues that Facebook Applications – small software applications on the site that have been marketed as games or ‘just for fun’ – are important in that they contribute to setting a playful mood on the site, although most of them do not fit into either a traditional game or play category.

Playfulness can be seen as an introduction to play and an attitude of the mind, a mood, that prepares for play (Rao, 2008). Playfulness, in this perspective, could be argued to be as important as play itself. Rao acknowledges that playfulness has become increasingly important to

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¹ Facebook. http://www.facebook.com/ (accessed 14-12-08)
consider in design of various leisure applications. Follett (2007) suggests that qualities of playfulness that could be in crucial to support in design are, for example, ‘fast rewards and a lot of positive feedback for user interaction’; ‘no negative consequences for experimentation’; and ‘interactive silliness’.

Computing in the Physical World

Ubicomp represents an idea of computing that takes place out in the real world – integrated with mobile devices and embedded into the physical environment – as opposed to in front of the desktop computer. This idea has to a large degree been made possible as mobile devices (e.g. laptops, handheld computers and mobile phones) along with hardware components (e.g. sensors, actuators, wireless networking modules, memories and batteries) have rapidly decreased in size and cost, and wireless networking has become available. Ubicomp offers new ways for people to interact with computers and the environment, but it also presents new challenges to designers as computing moves out from the well-controlled desktop environment to the complex and changing real world. As Dourish (2004) puts it: ‘when computation is moved “off the desktop”, then we suddenly need to keep track of where it has gone’ (pp. 19-20).

In an early vision of ubicomp, the late Mark Weiser, the ‘father of ubicomp’, envisioned a world where computers would disappear into the background of people’s lives and from there support them in a non-intrusive way as they could go on focusing on other tasks (Weiser, 1991). In such a world, Weiser imagined that computers would be innumerable, everywhere, interconnected, and exist in different sizes – from small components to wall-sized displays. He talked about computers in terms of ‘tabs’, ‘pads’ and ‘boards’; where tabs would be small computational entities the size of Post-Its that could be attached anywhere to keep track of things, pads would be the size of a sheet of paper, and boards would be the size of a blackboard. The real power of this concept, Weiser claimed, did not come from any of these devices alone but emerged from the interaction of all of them.

Weiser argued that a good tool should be invisible in use; not that it should disappear altogether, but that the user should be able to focus on the task rather than the tool (Weiser, 1994). As computers would be anywhere according to the vision, they had better to stay out of the way – a goal for ubiquitous computing was therefore to make computing calm and peripheral in order not to overwhelm people (Weiser and Seely Brown, 1996). As Weiser (1991) explains: ‘The hundreds of processors and displays are not a “user interface” like a mouse and windows, just a pleasant and effective “place” to get things done.’ Information was also supposed to be invisible when not needed, appearing only when we needed it and would thereafter automatically disappear into the periphery of our attention (Rogers, 2006).

In recent years, different aspects of Weiser’s vision have been explored further. Several platforms have been developed to facilitate embedded computing in the environment. The Smart-Its platform, for example, is a generic platform of small ‘computers’ that can be attached to everyday
objects to provide computing, sensing and communication (Holmquist et al., 2004). The Place Lab platform provides pervasive positioning for objects and devices both indoors and outdoors (e.g. LaMarca et al., 2005). Other platforms and technologies have augmented entire surfaces with embedded computing to facilitate networking and positioning of attached objects, which makes it possible to simply place objects on the surface to make them connected and able to communicate. Pin&Play is one example, where an augmented surface becomes a physical medium for both communication and power to objects that are attached to it (e.g. Van Laerhoven et al., 2003; Ljungblad et al., 2007). Using the Pin&Play technology, it is for instance possible to build smart notice boards where notes could inform people about approaching deadlines, or support for tasks that need large-scale surfaces, such as collaborative scheduling (Ljungblad et al., 2007). Other similar platforms for augmented networking surfaces are pushpin computing (Lifton and Paradiso, 2002) and Networked Surfaces (Scott et al., 2000). These platforms can be said to have addressed Weiser’s concepts of tabs and boards the size of entire walls or tables. Other projects have focused on large digital ‘boards’ that combine different types of information and ways of interacting. For example, Streiz et al. (1999) developed large touch-sensitive displays where on-screen digital information replaces physical artefacts, and users manipulate information directly on the screen. Klemmer et al. (2001) combined the manipulation of physical Post-It notes that are associated with digital information on a large digital display. A number of research projects on so-called ‘smart homes’, for example PlaceLab at MIT and Aware Home at Georgia Tech, have further explored using a collection of ubicomp technologies like the ones mentioned above in ‘home-like’, ‘intelligent’ environments. Rogers (2006) summarises the early attempts to reach Weiser’s vision:

‘A central aspiration running through these early efforts was that the environment, the home, and our possessions would be aware, adapt and respond to our varying comfort needs, individual moods and information requirements.’ (Rogers, 2006, p. 405)

Pervasive computing is another term that arguably denotes the underlying principles of ubiquitous computing and is often used as a synonym to it. A closely related field to both is tangible computing, which refers to interacting with digital information by using and manipulating tangible objects (e.g. Ishii and Ullmer, 1997). Another is wearable computing (e.g. Starner, 2001), which refers to computers that in different ways are worn on the body to augment various activities in a non-intrusive and ‘intelligent’ way. For the purpose of this thesis, no further description will be provided about tangible and wearable computing specifically. Instead, the following sections will consider the notions of context and context-aware computing, both central to this thesis. These notions are key in the field of ubicomp and pervasive computing, and context is widely discussed in HCI and CSCW as well.

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2 PlaceLab. http://architecture.mit.edu/house_n/ (accessed 14-12-08)
3 Aware Home. http://awarehome.imtc.gatech.edu/ (accessed 14-12-08)
Indeed, because of the significance of context-aware computing, it too has often been used as synonymous with ubicomp.

The Notion of Context and Context-Aware Computing

*Context* is widely discussed in the fields of ubicomp, HCI and social science, among others. As will become clear, there are diverse ideas in these fields of what context really refers to, but in the design of ubicomp systems it has often referred to various aspects of the surrounding environment that are possible to sense with sensors. Accordingly, *context-aware computing* means systems and devices that can sense aspects of the context using sensors, and react to this in order to perform some action that is relevant to the situation (e.g. Schilit and Theimer, 1994; Dey, 2001; Moran and Dourish, 2001). We will return to context-aware computing below.

The notion of *context* is one of the main challenges with sensing and reacting to the physical world. What does context refer to and what role does it play in interactive systems? In ubicomp and context-aware computing, there are numerous attempts to try to describe context, which mostly refer to what is possible to sense with sensors: time, location, co-located people, aspects of the physical environment like light and noise level, biophysical conditions of the user, etc. Schilit and Theimar (1994) initially referred to context as location, identities of nearby people and objects, and changes to those objects. Schmidt et al. (1999) later argued that there is more to context than location, and that we should consider further physical aspects of a setting. Dey et al. (2001) define context more extensively as:

> ‘any information that can be used to characterize the situation of entities (i.e. whether a person, place, or object) that are considered relevant to the interaction between a user and an application, including the user and the application themselves. Context is typically the location, identity and state of people, groups and computational and physical objects.’ (Dey et al., 2001, p. 106)

However, context is a much wider phenomenon than what is possible to sense with sensors, and a number of researchers within ubicomp and related fields are arguing that the above-mentioned ideas of context often fail to encompass crucial aspects of it. For instance, Chalmers (2004) and Dourish (2001, 2004) among others stress that context also derives from our social and cultural activities and practices – aspects that often have been and still are neglected in the design of context-aware systems, and are much more difficult to implement. In a particular context, then, people make sense of and negotiate what are important aspects of it based on what has happened previously, who happens to be there together, and what these people experience as important, etc. These are subjective, dynamic factors that are difficult to define in a system beforehand. Drawing upon sociological and philosophical foundations relevant to ubicomp and context-aware computing, Chalmers and Dourish put forward why we need to understand and consider such subjective context in design, besides objective context (e.g. information about the environment). One of the foundations is Suchman’s work on ‘situated actions’ (Suchman, 1987). Suchman criticised how many
computer systems were built on a plan-based approach to cognition, which meant that people would interact with systems based on well-defined plans and goals of what they want and need to do. However, as Suchman demonstrated, most activities are situated – they are negotiated and decided ad hoc on the spot, depending on the circumstances, e.g. social, available resources, etc. Drawing upon Suchman’s work, context is then dynamic and dependent on the situation, which further implies that it is difficult to define in a system beforehand.

Dourish (2004) brings up the difference between the positivistic approach to context, where context is something that is stable, separate from activity, objective and possible to encode, and the phenomenological approach, where context is looked upon as something that dynamically arises from activity in a particular situation and thus cannot be separated from it. According to the phenomenological approach, the problem with context is that it is something dynamic that is constantly renegotiated as we carry on doing things, and this negotiation gives meaning to the actions we do. Therefore, instead of asking ‘what is context and how can it be encoded?’ Dourish proposes an alternative view on context where we should ask ‘how and why, in the course of their interactions, do people achieve and maintain a mutual understanding of the context for their actions’ (Dourish, 2004, p. 22). Based on similar foundations, Chalmers (2004) proposes the use of historical context as an example of subjective context, since things we have done and experienced in the past strongly affect a current situation and contribute to the context in which things are done. Historical context could be used as a resource for a larger group of people, where for instance the past activities in a place in a city (e.g. what information people have searched for, sightseeing, taken photographs, etc) could become valuable for providing interesting information to new tourists in a context-aware tourist guide (Brown et al., 2005).

A rather different way of seeing context is to consider ‘coincidence’ as Reid (2008) does in the design of location-based games. A coincidence, according to Reid, is:

‘the noteworthy alignment of two or more events or circumstances without obvious casual connection. When a player experiences such a coincidence it feels “magical” and thus leads to feelings of wonder and excitement.’ (Reid, 2008, p. 21)

Reid (2008) argues that designers could design for different coincidences, e.g. natural and social, to happen in games, in order to increase the chance of players experiencing a ‘magical’ moment when playing the game. Designers would first need to get a deep understanding of the environment in which the game will take place, and then integrate characteristics of it in the game. In a game where natural coincidences would add something to the experience, it could be valuable to learn about for example typical weather conditions, animals, flowers, frequent activities, etc., and then integrated such aspects of the environment in the game.
Context-aware computing has emerged in parallel to ubicomp as an approach to computing facilitated by the same technological development of smaller, faster and cheaper components. One motivation behind much context-aware computing has been to build intelligent systems that can compensate for limitations in human cognition such as attention and memory (Rogers, 2006). Schilit and Theimer (1994) were the first to talk about context-aware computing and defined it as 'the ability of a mobile user’s applications to discover and react to changes in the environment they are situated in' (p. 23). Triggered by the increasing mobility of technology, they argued for the potential in making applications and devices adapt to a situation to provide more relevant and tailored information or services to users. Dey (2001) defines a context-aware system as one that ‘uses context to provide relevant information and/or services to the user, where relevancy depends on the user’s task’ (p. 5).

Others have described the aims of context-aware computing as to ‘acquire and utilize information about the context of a device to provide services that are appropriate to the particular people, place, time, events, and so forth’ (Moran and Dourish, 2001, p. 89). An overall aim or prerequisite in many context-aware computing systems has often been to map the physical environment, people and devices, as accurately as possible, in order to allow invisible, seamless and pro-active support of other tasks. According to Rogers (2006), key questions in context-aware computing involve what to sense, what form and what kind of information to represent to augment ongoing activities.

Initially, Schilit and Theimar (1994) used location information to detect nearby people and objects, as well as the changes to those objects over time. For example, the PARCTAB system allowed the detection of handheld computers in an indoor office environment (Schilit et al., 1993). The same concept was explored in the Active Badge system (Want et al., 1992), where an infrared device was worn as a badge and detected by beacons in the ceiling, which made it possible to accurately detect a person’s position in an office and communicate this information to other workers. As the idea of context-awareness was extended to outdoor settings, context-aware tour guides like the Cyberguide (Abowd et al., 1997) were built for mobile devices, which could present relevant information depending on where the user was located and thus tailor it to people and increase the utility. Similarly, Dey et al. (2001) implemented a Conference Assistant on a mobile device that would help people find relevant information as well as other participants at conferences. We will return to a few more recent examples later when presenting the use of aspects of context in leisure applications.

In context-aware computing, the predominant approach to augmenting devices with context information has been the pro-active one. This means that context information is mapped to various system behaviours (actions, responses, etc) performed automatically (see e.g. Tennenhouse, 2000), which is done to off-load certain tasks from the user and let him/her focus on other things, as illustrated in Weiser’s early vision of ubicomp. This processing of context information is often not made accessible or even perceivable to users and is handled in the background of the system. An example of a pro-active context-aware system is a meeting room that turns off the lights when it does not detect movement (Cooperstock, 1995).
Explicit and Implicit Interaction

The previous example of the meeting room also exemplifies the distinction between *explicit* and *implicit interaction*. On one level, explicit and implicit interaction can be talked about regarding the interaction with sensors (e.g. Rogers and Muller, 2005). Explicit interaction happens when the connection between sensor and activity is easily understood by the user because he/she gets instant feedback on his/her actions, for example when pressing a button. Implicit interaction applies to more passive interactions, such as when a user triggers a sensor, e.g. by being close to it but without necessarily needing to know what it takes to activate the application or when it happens. In the meeting room example, this means simply being present and active. Usually, sensors are specifically assigned to enable either explicit or implicit interaction, depending on the modalities of the application (Rogers and Muller, 2005).

On a more general level, explicit and implicit interaction refers to two ways of interacting with a computer or interactive system, where implicit interaction often is facilitated by sensor technology and/or machine intelligence. Buxton (1995, p. 240) introduced a model of foreground and background interaction to distinguish between ‘activities which are in the fore of human consciousness – intentional activities’ and ‘tasks that take place in the periphery – “behind” those in the foreground’. Again, an example of foreground interaction could be to manually and intentionally turn off the light in a room, and background interaction could be when the light is automatically turned off as one leaves the room. *Direct manipulation* and *indirect manipulation* (Shneiderman and Maes, 1997) are two other ways of interacting with a computer system that we will return to again later. Direct manipulation refers to the user’s explicit and controlled interaction in a graphical user interface (GUI), and implicit interaction refers to offloading certain tasks to software agents that can autonomously perform these tasks while the user is doing something else. Schmidt (2000) proposes *implicit human-computer interaction* through the use of context, that is, sensor-based information about aspects of the physical environment. Schmidt imagines that implicit interaction could for instance involve changed systems settings depending on conditions in the physical environment that a user finds herself in. Related to Schmidt’s approach, Hinkley et al. (2005) use Buxton’s model above (Buxton, 1995) to understand interaction with sensor-enhanced mobile devices, and in particular what transitions between foreground and background interaction could imply for the implementation of such devices. Finally, Ju and Leifer (2008) propose a design-based approach to understanding implicit interaction in order to complement the more technology-oriented approaches like the ones above. It involves using social theory to analyse and better understand everyday interactions between humans, and between humans and devices, for the purpose of designing interactive systems using implicit interaction.

A Broader View of Ubicomp

Several aspects of the field of ubicomp and context-aware computing have been criticised. Weiser’s vision has strongly influenced ubicomp since the
90's, and some researchers have recently argued that it brings with it unrealistic goals of how computing should be implemented in the physical world (Rogers, 2006; Bell and Dourish, 2007). Rogers (2006) argues that the vision of sensing and reacting to the world as attempted in ubicomp is unrealistic, because it is impossible to implement context and make 'sensible predictions about what someone is feeling, wanting or needing at a given moment' (p. 405). Rogers also questions the idea of calm computing (e.g. Weiser and Seely Brown, 1996) from an ethical and social perspective, and asks whether we would want to live in such a world, had the vision been possible to reach. It has also been argued that it is no longer relevant to speak of a ubicomp vision, as the world we live in has in many ways already become a ubiquitous computing world (Bell and Dourish, 2007). It is however not exactly as Weiser envisioned – instead, the most ubiquitous device in our everyday life has become the mobile phone, which has brought with it fundamental changes in the way we communicate with each other and achieve things. Rather than talking about a vision to be realised in the future, Bell and Dourish stress that we should turn our attention to what is already happening and possible today. Others have brought up the question of privacy of users, as many ubicomp systems involve continuous monitoring, tracking and logging of for instance people and objects to be able to perform (e.g. Palen and Dourish, 2003; Anderson and Dourish, 2005; Rogers, 2006). Related is Chalmers and Galani’s (2004) critique of the ‘disappearance’ mentioned by Weiser as a goal for ubicomp. According to Weiser’s vision, ubicomp systems should allow seamless interaction, where the technology and the activity are so tightly coupled that they become a whole. The technology would in such a way disappear, because it would be an inseparable part of the everyday. Chalmers and Galani argue that the ideal of disappearance is misleading. On the one hand it is unachievable because of the complexity and dynamics of the real world, which will cause breakdowns and unexpected situations. On the other hand it is not the case that we all the time seamlessly interact with technology – users of ubicomp technology will also need to bring the technology to the foreground, and reflect upon what is happening, for instance when learning to use a new tool. Instead, they propose a ‘seamful’ design approach that makes the infrastructure of a system visible to the user, who can then use this to better understand the functionality. In a similar way, others have suggested that users themselves should be allowed to describe their context to a context-aware system, in order to have more control over what aspects of a situation would influence a system, which could hopefully fit users’ situations better and increase the understanding of the system (e.g. Barkhuus, 2004).

Many research efforts in the field of ubicomp have further been criticised for their dominant focus on technical solutions and little concern about the intended users, and for the overall shortage of studies with users in real life in ubicomp. Furthermore, the field of ubicomp has until recently focused to a large extent on work settings where the office is the given environment, and left out other parts of life like domestic life (e.g. Tomie et al., 2002). Based on ethnographic studies of domestic life, several researchers bring to
light the challenges in ubicomp to go beyond simply making technology ‘invisible’ and ‘intelligent’, and instead look at how technology could become a resource in our everyday life that is already filled with routines and actions (e.g. Tomie et al., 2002; Taylor et al., 2007). Focusing on users, but from a different perspective, is Rogers’ proposal of a new agenda for ubicomp that would focus on designing technologies for engaging user experiences (Rogers, 2006). As opposed to pro-active computing where devices make decisions for, and sometimes in spite of the user, this approach means designing for pro-active people – not systems – who would become more actively engaged in what they do. Playful and learning practices, scientific practices, and persuasive practices are some examples of application areas where ubiquitous computing technologies can be exploited in design, in order to create more engaging and meaningful experiences for users. Such systems would help users change habits and take control over situations, or help them in a learning process through interaction with and exploration of physical-digital spaces.

Leisure and Design of Information Technology

HCI and CSCW have a long fundamental tradition in design and studies of work systems, and as we have previously seen, ubicomp initially had a similar focus on utilitarian and task-oriented research. However, in recent years the general interest in these fields has come to include areas such as leisure and domestic life. First, researchers have recognised that people not only work, but also spend a significant time engaged in different leisure activities. Second, novel technologies offer great opportunities to design for leisure.

In HCI and CSCW the interest in leisure increased as people, in particular young people, adopted communication technologies like instant messaging (IM) and mobile phones for leisure purposes (Weilenmann and Larsson, 2001; Grinter and Palen, 2002; Taylor and Harper, 2002). Games of all kinds have also received attention (e.g. Brown and Bell, 2004), and lately the exploding popularity of social networking sites point at another leisure domain that is worth interest (e.g. boyd, 2007). As several researchers have argued (Holmquist et al., 1999; Brown and Barkhuus, 2007), it is worth taking leisure practices seriously – partly because they are clearly important in many people’s lives, and partly because studies of them contribute with valuable knowledge about our relationship to technology in everyday life. Many leisure activities are inherently collaborative, and learning about them can be beneficial for other social domains as well.

Defining leisure is however not easy, and making a sharp divide between work and leisure (or domestic/home life and leisure) becomes increasingly problematic as they are often intertwined in our current society (Brown and Barkhuus, 2007; Perry and Rachovides, 2007). For instance, the involvement in social networking sites is clearly part of leisure but can be related to work activities as well, and leisure in the home is often interwoven with other home activities. Perry and Rachovides further call for a broadening of the
notion of leisure-based activities, arguing that leisure is often too narrowly defined within the design community as a:

‘highly dedicated and focussed activity [...] enacted through game playing or media consumption (often using what we have come to call ‘entertainment technologies’), when in practice, it is much more subtle and diffuse than this’. (Perry and Rachovides, 2007, p. 100)

Considering leisure in terms of gaming, television, and audio-visual media consumption, as often defined by the entertainment industry, we can broaden our notion of leisure to a variety of everyday playful and creative activities done with technology for social and individual purposes (Perry and Rachovides, 2007). Doing this, it is important to acknowledge leisure as something that does not need to be highly engaged play, and as something that can involve more reflective activities as well. This can then include applications for tourism (e.g. Brown et al., 2005), collaborative music sharing (e.g. Brown et al., 2001), exploratory music making (Gaye and Holmquist, 2006), photo exploration using mobile devices (e.g. Rost et al., 2008), playful messaging (Perry and Rachovides, 2007), and playful home decoration objects (Gaver et al., 2004; Gaver et al., 2006; Gaver et al., 2008) that we will return to later in a section about so-called ‘ludic design’.

Beyond Usability

What is common for the research activities on leisure above – whether it be games, music sharing or playful messaging – is that they encounter new challenges in design when the goal no longer is to support tasks or increase the efficiency and ease of use, as in the design of work systems. Technologies that allow people to be explorative, engaged, creative, develop a skill, enjoy themselves and have fun, introduce new sets of values that are increasingly relevant to consider in design. For instance, in some applications it is not the quickest road to a goal – winning a game or mastering a new music-making tool – that is the most fulfilling, but the exploration towards it. Other recent related research efforts face similar challenges when they explore how to design for emotions, affect and bodily expressions (e.g. Sundström et al., 2007), fun (Blythe et al., 2003), intimacy (Kaye et al., 2005; Kaye, 2006), engagement (Rogers, 2006), and aesthetic interaction (Graves Petersen et al., 2004).

Designing for and evaluating values beyond usability and efficiency have become the focus of an emerging area in HCI called experience-centred design. This area has during recent years attempted to take a more holistic approach to technology use and design of technology. Looking at people’s experiences with technology, it emphasises that technology is much more than usability, efficiency and utility – technology has become a part of our ordinary life and we react to it emotionally, intellectually and sensually; aspects that we need to understanding and consider when designing technology (Wright et al., 2003; McCarthy and Wright, 2004). Users of technology are not passive nor do they encounter technology empty-handed – they subjectively interpret, make sense of and appropriate technology based on many factors, including previous experiences they have (McCarthy and Wright, 2004). The notion of
experiences is not new – disciplines such as the humanities, arts and social sciences have a long tradition of studying and trying to understand the complexity of experiences (Wright et al., 2003; McCarthy and Wright, 2004; Kaye and Taylor, 2006). Ethnographic research has for a long time aimed at understanding practices in depth. However, as a field, HCI has previously lacked ways of talking about, understanding and dealing with experience-related issues (Sengers, 2003). With its strong roots in engineering and psychology, Sengers explains, HCI has gained an expertise in modelling, measuring and optimising human-computer interaction, rather than dealing with multiple and complex interpretations and experiences. As Sengers (2003, p. 20) exemplifies: ‘it [HCI] often focuses on rationalized and optimised techniques to understand and engineer human experience – even if the goal is fun’.

A body of work has therefore recently stressed the need for new experience-centred methods for design and evaluation in HCI, as previous ones are not suitable and even fail to completely capture the complexity of our relationship to technology as it appears in all corners of everyday life (e.g. Harrison et al., 2007; Kaye and Sengers, 2007; Kaye, 2009). Kaye (2009) refers to these efforts as experience-focused HCI and stresses the need for not only more suitable methods for evaluation, but also of a more careful epistemological reflection in HCI about what kind of knowledge we create. Attempts to ‘re-think’ methods have explored the potential value of multiple interpretations (Sengers and Gaver, 2006), where the purpose is not to design for or evaluate one correct ready-made meaning but to make it possible for users to create their own individual meanings as this is often more engaging. Another attempt has been to borrow techniques and influences from e.g. the humanities and arts. For instance, this has previously involved exploiting rich descriptions of fiction in brainstorming activities (Blythe, 2004) and inviting cultural commentators for new and wider perspectives on one’s design (Gaver, 2007). Others have explored design principles that could allow and support new values in the interaction with technology. One principle is to embrace randomness to allow spontaneity and serendipity (Leong et al., 2006), or to use ambiguity as a resource in design (Gaver et al., 2003), which in turn could allow users to create their own interpretations and meaning of the technology (Sengers and Gaver, 2006).

Ludic Design

We will now return to Huizinga’s theory about play (Huizinga, 1955). In combination with novel ubicomp technology, Huizinga’s ideas have been used to explore a design concept called ‘ludic design’, or ‘ludic engagement’ and ‘everyday play’ (e.g. Gaver, 2002; Gaver et al., 2004; Gaver, 2006), in which values such as playfulness, reflection, curiosity and exploration have been promoted in the design of technology. Here, Huizinga’s work has come to serve as an overall motivation for designing technology that focuses on other values and aspects in life, besides work and task-oriented activities:

‘The idea of Homo Ludens […] is an antidote to assumptions that technology should provide clear, efficient solutions to practical problems. From this perspective, we are characterised not just by our thinking or achievements,
but by our playfulness: our curiosity, our love of diversion, our explorations, inventions and wonder.’ (Gaver, 2002)

Ludic activities are thus not work-related or designed for anything in particular, but they are neither a ‘simple matter of entertainment, or wasting time’ (Gaver et al., 2004, p. 886). Gaver et al. (2004) propose that ludic activities sit between existing genres like entertainment, art, communication, toys, information and tools, without explicitly belonging to any of them. The elements of reflection, exploration and meaning-making make ludic design different from mainstream leisure and entertainment applications, and they bring up other kinds of design challenges. Rather than providing a ‘ready-made’ concept or experience, ludic design objects allow the user to explore and interpret an application in the way he or she prefers – they raise issues and questions, but do not provide any answers (Gaver, 2002). Important rationale include promoting curiosity, exploration and production of meaning; de-emphasising task-oriented activities and thus stressing that a system or device is for non-utilitarian purposes; and making it ambiguous to leave it open for people to create their own interpretations of the system (Gaver et al., 2004). Ludic design has further been developed as a critical standpoint towards much of the work- and task-oriented research within HCI, which is arguably taking a too one-dimensional view of what we could do with technology:

‘In the context of HCI, ludic design explores the limits of technology design practice – what it is we may design for, what methods we may use – by proposing a specific set of values that contrast sharply with those currently at the center of technical practice: functionality, efficiency, optimality, task focus.’ (Sengers et al., 2005, p. 52)

Ludic design has been explored in domestic environments as intriguing pieces of furniture and home decoration objects (e.g. Gaver et al., 2004; Gaver et al., 2006; Gaver et al., 2008), and in housing estate environments as thought-provoking outdoor furniture and installations (Gaver, 2002). An example of a ludic design object is the Drift Table – a coffee table that encourages the exploration of satellite maps of England and Wales (Gaver et al., 2004). The table has a small porthole in the middle where the map is showing, and is equipped with hidden sensing technology that can sense objects (weights) that are put on the table surface. Placing objects somewhere will decide the direction and speed in which the table is ‘drifting’ on the map. Following the design principles above, the point of the Drift Table is not to support conventional map activities like finding the shortest route from A to B, but to open for explorative activities and meaning making according to people’s own interests (Gaver et al., 2004).

Using Aspects of Context in Leisure Applications

So far we have introduced ubicomp including context-aware computing as an approach to doing computing in the physical world, the importance of designing for play and leisure practices, and the new challenges it brings with it. In the section below, we will look at examples of mobile applications
that make use of ubicomp technology and aspects of context in their design to open for a range of leisure activities.

Supporting Photography with Context-Awareness

The following systems each gives an example of how context-aware computing has been used to support different tasks in photo practices. In the ‘context-aware camera’ (Holleis et al., 2005), sensor-based information (e.g. about the photographer’s movements) is gathered to support people in taking ‘better’ pictures. Users get immediate feedback about how they took a picture, in order to suggest adjustments and other tips to help them become better at it. Information from sensors has also been used to tag pictures and facilitate browsing through image or video databases. LAFCam (Lockerd and Mueller, 2002) automatically detects laughter to index video recording with points of interest. StartleCam (Healey and Picard, 1998) uses a skin conductivity sensor to measure excitement, which triggers a video camera to automatically start recording potentially interesting content. In these three examples, sensor-based information is invisible to the user and handled by the system in the background, and certain actions are performed automatically based on sensor readings so that the user can carry on whatever s/he is doing. A related, commercial example is the ‘Smile Shutter’ technology4 from Sony that automatically detects when one or more persons are smiling to trigger taking a picture in digital cameras.

Providing Social Awareness

Sensors and wireless communication technologies have been used to detect other nearby connected users to provide a social awareness, which is often integrated with other functionality (e.g. media sharing, see Bassoli et al., 2006). In an early example, the Meme Tag (Borovoy et al., 1998), an enhanced name tag for conferences and similar events, used infrared communication to identify other tags and thus people in the proximity in order to increase the awareness of and trigger interaction with other users with similar profiles. Another early example is the Hummingbird (Holmquist et al., 1999), which used mobile devices with radio transceivers to alert people when other users were nearby, and thus facilitating social awareness. The matchmaking system Social Serendipity (Eagle and Pentland, 2005) used Bluetooth to detect nearby users and then compare their profiles – if matching interests are found, the system alerts the users and suggests face-to-face interactions. In the recent Motion Presence application on mobile phones, cell IDs are used to determine motion status and let users automatically see if their connected friends are ‘moving’ or ‘not moving’ and for how long they have been in that state, and thus get a sense of what they are doing (Bentley and Metcalf, 2007). With Jabberwocky, Paulos and Goodman (2004) took a different approach to social awareness that did not involve connecting unacquainted people as a kind of matchmaking device. Jabberwocky is an experimental system based on iMotes – small, embedded processors with wireless connectivity that register and log activities around them – together with a mobile phone interface. The system detects and

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4 Smile Shutter technology, Sony. http://www.sony.com/ (accessed 14-12-08)
records over time the presence of so-called familiar strangers (Milgram, 1977) – people who we regularly observe but do not interact with – in everyday life and then presents it in an abstract way on the mobile phone interface. The purpose was to increase the awareness of people one encounters and the places one go to in everyday life for reflection rather than matchmaking.

Facilitating Games in the Physical World
Ubicomp technologies have been used to facilitate completely new game experiences in the physical world. A commercial example is the Nintendo Wii5, which uses sensor-enhanced equipment to allow users to physically interact with and play computer games, e.g. in different kinds of sport games. An increasing number of games have been released lately for the iPhone6, where its integrated sensors (such as accelerometer) make it possible to physically interact with a game, for instance to make an object move on the screen. In academic research, an emerging area involving so-called pervasive games, mobile mixed reality games and location-based games, explores gaming that takes place in the physical world. Can You See Me Now (CYSMN) is a game of catch involving both online and real-world players, where the real-world players move through a real city to catch online players who participate in a corresponding virtual city (Benford et al., 2006). The real world players are equipped with handheld computers with WiFi and GPS receivers that allow them to see on a map where the online players are located. Treasure (Barkhuus et al., 2005) and Feeding Yoshi (Bell et al., 2006) are two location-based mobile multiplayer games that each exploits ‘seamful design’. In these two cases, seamless design means that wireless network’s ‘seams’ are made visible to the players as a real-time resource in playing the game. In Feeding Yoshi, players need to explore whether a WiFi hotspot is open or secure, since it matters when achieving certain things in the game. In Treasure, players can develop strategies benefiting from both good and poor network coverage – poor coverage can for instance make it possible to hide one’s visibility from other players. CYSMN, Treasure and Feeding Yoshi have in common that uncertainties such as network disconnections and uncertain GPS positioning are encouraged to be seen as features and opportunities in gameplay, rather than bugs that need to be prevented in design.

Adding New Dimensions to Mobile Media
Sensor-based information about the surrounding environment has also been used in mobile media applications to add new dimensions in terms of sharing, consuming or creating media. The presence of nearby users has been used to turn the usually private listening on mobile music devices into a more social experience. tunA (Bassoli et al., 2006) is a mobile peer-to-peer music sharing application which detects nearby users using WiFi and allows ‘tuning in’ to eavesdrop on these users’ playlists, which causes music to be streamed between devices. SoundPryer (Östergren and Juhlin, 2006) is a mobile media sharing application for cars where music is streamed between

5 Nintendo Wii. http://www.nintendo.com (accessed 14-12-08)
encountering cars to create a shared music experience in traffic. The location can also be used to filter media based on where you are and thus allow a new browsing experience. Zurfer\(^7\) is a location-based photo browser for mobile phones that makes it possible for users to browse pictures that were taken close to or at their current location. Different kinds of sensor-based information have also been explored as resources when creating mobile media. Sonic City (Gaye et al., 2003) is a wearable system that turns the city into an interface for real time electronic music making. In Sonic City, sensor information from the urban environment is gathered as the user is walking or moving about, and used in real time to create electronic music.

**Encouraging Changing Behaviour and Reflection**

An increasing number of mobile applications are using sensor-based information to increase users’ awareness of health aspects, such as their physical activity, and recently, of environmental issues (Paulos et al., 2007; Aoki et al., 2008). Shakra (Anderson et al., 2007) is an application running on mobile phones that tracks daily physical activity levels using GSM signal strength and shares this between groups of friends to facilitate awareness and encourage further activity. The UbiFit Garden (Consolvo et al., 2008) is another system for monitoring and promoting physical activity, which uses on-body sensing together with a mobile phone application that can detect, at least to some degree, what kind of physical activity is undertaken. A related application, the Affective Diary (Lindström et al., 2006), is designed to encourage users to reflect on their own lives, thoughts and emotions. The Affective Diary combines individual sensor data such as movement and arousal, with personal content such as received text messages, MMS, pictures, etc., and presents this together in an ambiguous way in a timeline interface. It is the user who then decides how she or he wants to interpret and think about the collected information.

**Encouraging Exploration of the Physical Environment**

Since the advent of context-aware computing, location has been an important aspect of the physical environment to sense and use in design, and early examples of context-aware tourist guides were built to present relevant information depending on where the user was located (Abowd et al., 1997). Similarly, a range of applications for mobile phones now offer users relevant information about for instance restaurants, based on a given location. However, location information has also been exploited to allow for more exploratory ways of seeing the physical environment in overlapping fields such as urban computing, locative media and location-based computing. For instance, in the George Square tourist system (Brown et al., 2005), users can collaboratively explore a physical place with distant friends and family over the Internet, using a GPS and WiFi equipped mobile device. Rather than merely providing relevant tourist information for a place, an important aspect of the system is to open up the possibility for sociability.

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\(^7\)Yahoo Zurfer. http://zurfer.research.yahoo.com/ (accessed 14-12-08)
In locative media applications, digital media is tied to a physical place to add a new layer of information to that place for various purposes. In the GeoNotes system (Persson et al., 2002), users could write virtual Post-Its, name their location and post them to a physical place for later exploration by others. In Columbus (Rost et al., 2008), users can explore GPS-tagged digital images from Flickr based on where they are located – the application is deliberately limited to showing only local pictures, so that users need to physically move to the place to look at the images.

Sensor-based information about the physical environment has been used in various ways in urban computing to shed light on new aspects of a city, and show this to users for reflection, playful exploration, social encounters, etc. One example is Hullabaloo (Paulos et al., 2008), an interactive sound installation for public urban places that picks up Bluetooth signals from the phones of passers-by and then broadcasts a unique sound for each passer-by. In deployments of the system, the public aspect of Hullabaloo generated curiosity and speculations among passers-by both about the system in itself, and about other people nearby and the surroundings.

Bringing Agency and Autonomy into Systems

As seen previously regarding ubicomp and context-aware computing, digital technology and sensor technology make it possible to build computer systems that sense aspects of their surrounding physical environment and act accordingly. For example, pro-active systems automatically perform certain tasks based on sensor data about a physical setting and some given rules of action – it could involve automatically turning the lights off in a room when no one is in it (Cooperstock, 1995). Such possibilities have given rise to two main ways of interacting with sensor-based systems, which have been referred to as explicit and implicit interaction or similar (Buxton, 1995; Schmidt, 2000; Rogers and Muller, 2005; Ju and Leifer, 2008). In this final section of related background work, we will turn to the field of AI, in which there exists a similar tension between ‘explicit interaction’ that is initiated and controlled by humans, and ‘implicit interaction’ that in the AI tradition is triggered by machines and systems that possess qualities of agency and autonomy – many times in combination with sensor-based information about the physical environment.

The field of AI emerged in the 1950’s, motivated by an aim to investigate how machines and systems could be given some ‘intelligence’ and based on that, successfully perform actions and tasks autonomously (Grudin, 2006). Early investigations of AI research – called classical AI or strong AI – aimed at building machines that essentially had the same intelligence and mind as humans, or even to outperform humans (Winograd and Flores, 1985; Winograd, 2006; Leahu et al., 2008). This however proved to be more difficult to achieve as a whole than expected. AI research therefore identified individual capabilities of mind, for instance language, memory, and reasoning, which were investigated separately and later meant to be combined into a complete intelligent system (Leahu et al., 2008). Again, AI researchers realised that this was more complex than expected, simply
because these individual areas are connected and rely on each other. Weak AI, in contrast to strong AI, is an approach that does not aim at building machines that have a complete intelligence and mind, but rather simulate aspects of intelligence (Searle, 1980). The approaches of strong and weak AI both look upon machine intelligence as disembodied, that is, without considering the world around of humans, context, etc.

More recent attempts in AI have aimed at avoiding the apparent difficulties in strong AI by focusing on smaller areas and domain-specific problems in situated contexts, rather than solving the general problem of intelligence (Grudin, 2006; Leahu et al., 2008). Leahu et al. refer to these approaches as ‘interactionist AI’, which provide ‘concrete, technically feasible approaches for supporting real-time, intelligent interaction with a changing environment’ (p. 135). In interactionist AI, intelligence or some behaviour that is interpreted as intelligent, emerge from the interaction between the user, the system and the environment, as opposed to in the system itself as in strong and weak AI. Therefore, topics of interest include human interpretation of and interaction with intelligent systems. As interactionist AI takes in the dynamic physical environment with people who live in certain cultural and social contexts, it also considers more dimensions in design (Leahu et al., 2008).

Agents of different kinds are used to address domain-specific problems in situated contexts. Here, the aim is thus not to build a complete intelligent system, but an entity that fits an environment and can react to it in certain ways. An agent is a computational entity that has goals, sensors and effectors; that can decide autonomously which actions to take in the current situation; and that can learn or adapt to improve its effectiveness (Maes and Wexelblat, 1996). Agents exist from very simple to extremely complex ones; they can take physical shapes as in robots, or consist of software programs. For the purpose of this thesis, we will leave physical agents to one side, and focus on software agents. A software agent inhabits the world of computers and networks and ‘knows’ users’ interests, habits and preferences and can act autonomously based on them (Maes, 1996; Maes and Wexelblat, 1996; Shneiderman and Maes, 1997).

In the 1990’s, Maes (1994; 1996) proposed the use of software agents to reduce work and information load on users – for example with the exploding Internet in mind. Using software agents, users could delegate certain tasks to such agents, and then engage in a style of HCI that has been referred to as indirect manipulation (Maes, 1994; Maes and Wexelblat, 1996). This generated a large debate (Shneiderman and Maes, 1997) about indirect manipulation versus direct manipulation (Shneiderman, 1992), which had been the dominant way for users to interact with graphical user interfaces. As opposed to direct manipulation of interfaces, which gives total control to users (Shneiderman and Maes, 1997) and requires that they initiate all tasks explicitly as well as monitor all events (Maes, 1994), indirect manipulation would mean that some control is given to software agents to perform certain tasks. As Maes (1994) points out, in indirect manipulation ‘the user is engaged in a cooperative process in which human and computer agents both initiate
communication, monitor events and perform tasks’ (p. 31), but where the user still has a final say in what is happening.

In the debate, Sheiderman argued that it is necessary to design systems where users can understand and predict the interface and therefore trust it, where they are in control and thus feel that they are responsible for their actions (Shneiderman and Maes, 1997). Software agents, Shneiderman claimed, are unpredictable and uncontrollable. On the other hand, Maes believed that as available digital information was exploding and computers had become more complex, users needed help in finding certain information, and that software agents could do this for them. Agents could even make suggestions about something that the user had not thought of before, and Maes claimed that people sometimes enjoy not having to make active decisions about everything. Although this means letting go of some amount of control to software agents, Maes stressed that users should still be in control of making final decisions, and that software agents are not suitable for all kinds of tasks, which would exclude critical ones. Moreover, software agents should be seen as a complement to direct manipulation, rather than an alternative (Shneiderman and Maes, 1997).

Agent-based systems also face complex technical challenges, and as mentioned, they bring up important questions and concerns related to how they are interpreted and accepted in the interaction and communication with humans (e.g. Leahu et al., 2008). However, keeping in mind that agent technology might not suit all kinds of situations and tasks, there are situations and areas where agents are already successfully used and where agents become a valuable resource in the interaction. Several of the examples below belong to a broad leisure domain where reasons for using agents are more diverse than for the purpose of offloading tasks. Recommender systems are one example, which was also one of Maes’ early application areas for software agents (Shneiderman and Maes, 1997). Recommender systems can give people useful as well as unexpected recommendations about films, books, music, etc., based on what they usually consume and prefer. An often referred to example is Amazon8. Embodied agents are another example, referring to various kinds of agents that can take physical or virtual forms, and exist for instance in conversational/dialogue systems or as characters in games. As Mateas describes, AI techniques including agents are also used in games to create an important sense of aliveness:

‘game AI is not just about hyperrational problem solving, but also about creating a sense of aliveness, the sense that there is an entity living within the computer that has its own life independently of the player and cares about how the player’s actions impact this life.’ (Mateas, 2003, pp. 2-3)

Another area in which agents have been used as a resource in the interaction with humans is art. Computers and computational power in general have been used in art practices since the 1960’s, for example by generating new

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8 Amazon. http://www.amazon.com/ (accessed 14-12-08)
kinds of art such as computer-generated graphics (Candy and Edmonds, 2002). In art practices, reasons for building systems with agency and autonomy are, among other things, to offer new unexpected input and experiences that can bring new inspiration into the creative process, or even make the computer become a ‘co-creator’ or ‘partner’ of a sort in the creative process (Lubart, 2005). According to Lubert, this idea is based on work in AI where computers themselves can become ‘creative’, or contribute with new ideas and inspiration. He brings up the example of a jazz improvisation programme that produces different musical sequences according to a set of rules worked out by jazz musicians. Although these ideas have been criticised on similar grounds as classical AI (Lubart, 2005), they still illustrate the ways a computer system with agency and autonomy can become a resource in the interaction, rather than offloading a task. Software agents have also been used in interactive art installations to change the object together with the artist and the viewers, for instance over time, depending on the history of interactions with the work, and/or sensor-based information about the surroundings (Candy and Edmonds, 2002). Positioned on the boarder of AI, HCI and art, Mateas (2001; 2003) has developed an interdisciplinary agenda called Expressive AI, in which the focus is switched from the AI system itself to exploring its role in the communication between the author/artist and the audience.

Lastly, we will turn to design-oriented research in HCI and ubicomp, where a number of recent projects are exploring the use of agency and autonomy – or behaviour that is interpreted as well as questioned by users as intelligent – in systems designed for the home. Two aims here are to investigate new experiences with such technology, and to explore relations between system and users, along with interpretations and understanding of living with ‘intelligent’ systems in the home. The following two examples are also designed as criticisms of how task-oriented ‘smart homes’ (e.g. Abowd and Mynatt, 2000) have been developed and modelled in the field of ubiquitous computing.

The Home Health Horoscope system (Gaver et al., 2007) and the Tableau Machine (Pousman et al., 2008) both invite reflection from the members of a household. They do this by sensing various aspects of a home, e.g. activity, and then providing ambiguous and intriguing output based on the sensor data. In both systems it is left to the household members to interpret, reflect on and make meaning from the output. The Home Health Horoscope system provides daily automatically printed messages in the form of ambiguous ‘horoscopes’ for the household, without using AI, and the point is to engage the members in creating meaningful interpretations of the horoscopes. Through the meaning making and interpretation done by the household members, questions arose about the system in a long-term study and whether the system really was able to sense the ‘wellbeing’ of the household and give a matching output. This was in line with the aim of ‘shift[ing] the responsibility for meaningful interpretation from the system to the user’ (Gaver et al., 2007, p. 537). The system could be seen as ‘taking a role as another voice in the household, rather than an authority’ (Gaver et al., 2007, p. 545) that spurred discussions about wellbeing, even if the members did not agree with the
judgements it made based on sensor data. Based on sensor-based information, the Tableau Machine continuously expresses ambiguous visual ‘machine-like compositions’ on a digital display placed in the home. As Pousman et al. (2008) explain:

‘By avoiding simple one-to-one mappings between data and display, the household has more space to engage in co-interpretation, that is, for the system to serve as a provocation rather than a simple reporter of the state of the home. If done correctly, householders should have the sense of the system as an independent, non-human subject, who has its own interpretation of the activity engaged in by the user’ (Pousman et al., 2008, p. 371)

Similarly to the Home Health Horoscope system, the Tableau Machine is thus designed to ‘take the role as another voice’ that actively and autonomously participates in the meaning making about the state of the home. This turned out to be important for the engagement with the system. During its deployment in households, the families attributed personality to the Tableau Machine, and developed feeling of intimacy towards it as a social presence in the home.

This section has briefly illustrated how the field of AI started with grand ideas about intelligence in machines, regardless of humans and context, to continue with more small-scale and context-specific solutions that interact with humans and the physical environment. As seen, these context-specific AI systems can become valuable resources in leisure and creative applications where they, through implicit interaction, can generate unexpectedness, inspiration, aliveness, and provoke discussions and reflection.
Chapter 3

Defining the Design Space

Before continuing to the method and the case studies of the thesis, the following brief chapter will define the design space of this work by revisiting elements of the background and explaining why they are relevant, and in some cases, why they are approached differently here. In particular, this chapter will revisit the definitions of mobile media, play, context, agency, and autonomy. For the purpose of this thesis, mobile media is defined as any kind of media (images, video, sound, text, etc) that is consumed, created and/or distributed on personal mobile devices.

As seen, play is a much wider phenomenon than games, and should not be likened to ‘mere’ entertainment or only highly energetic activities (Huizinga, 1955; Gaver, 2002; Perry and Rachovides, 2007). For example, in this sense, the passive TV-viewer is not playing, and neither is the person who is playing some random game on his mobile phone to simply kill time. Play can also involve reflective, imaginary, creative, and explorative activities, which are playful and yet at the same time serious and mindful. This wider definition of play is embraced in the present thesis, which is not about gaming or mere entertainment, but aims to show other forms of playful activities within the leisure domain – in this case with mobile media on mobile phones.

This work is related to the concept of ludic design (e.g. Gaver, 2002), but differs in at least two ways. First, it does not aim to bring forward the same explicit critical component, although there is no disagreement about its value to the HCI discourse. Second, the work presented here explores playful activities in a rather different domain – mobile media on mobile phones – compared to ludic design that has primarily been explored in domestic and public settings. Ludic design objects are further rather exclusive and tailor-made (e.g. Gaver et al., 2004; 2006; 2008), whereas the work in this thesis explores more ordinary and pervasive mobile devices as platforms, similar to the research done by Paulos et al. (2008). In fact, the mobile phone is an interesting technical platform on which to design for playful activities. Because of its pervasiveness in everyday life, it matches Huizinga’s idea well that anyone could become engaged in play at any time and anywhere (Huizinga, 1955).

The aim is thus to design mobile media applications for playful purposes on mobile phones, and exploit technical opportunities facilitated by ubicomp technologies to take in aspects of the surrounding physical and social context. It is crucial to make clear here that aspects of context refer to aspects of the immediate physical surrounding – outside of the device – that can be identified
and measured by sensors. Therefore, exploiting aspects of context in design means the use of different kinds of sensor-based information. As opposed to other parts of research in ubicomp and context-aware computing, this work is not based on the view that such information can be used to model context for the purpose of context-aware support. However, as suggested, sensor-based information about aspects of the physical surroundings could still become a resource that makes new dimensions and interaction possible in design and use. This approach is therefore similar to how aspects of context have been used in the design of other leisure applications seen in the previous chapter. Rather than facilitating context-aware support, we have seen how sensor-based information can allow music sharing between people who happen to be in the proximity of each other (e.g. Bassoli et al., 2006; Östergren and Juhlin, 2006), open for new types of games in the physical world (e.g. Barkhuus et al., 2005), and allow new ways of creating media by moving in an urban environment (e.g. Gaye et al., 2003).

Furthermore, as the aim is to design for playful activities where the user is encouraged to playfully engage with mobile media, the approach is to find ways of using sensor-based information about the surroundings that support engaged and active people (Rogers, 2006), rather than pro-active context-aware systems. As seen in the fields of AI and HCI, qualities of agency and autonomy can be used to introduce unexpectedness and spontaneity in the interaction with leisure applications that in turn can inspire art installations (Candy and Edmonds, 2002; Lubart, 2005) and engagement and reflection in applications for the home (Gaver et al., 2007; Pousman et al., 2008). Therefore, in this thesis, sensor-based information about the surroundings is used together with computational power not only to give agency and autonomy to users, but also in some degree to the applications, as one approach to explore how to design for and encourage play. In doing this, the interest lies in users’ use, reflections, and interpretation of the systems, rather than the technical solutions with respect to AI, which is similar to the work by Gaver et al. (2007) and Pousman et al. (2008).

Summing up the chapter, the design space in this thesis consists of:

- any kind of mobile media on mobile phones;
- a wider definition of play that includes reflective, creative and explorative activities in everyday life;
- aspects of the physical and social context that are possible to sense with sensors, which should support people’s engagement rather than supporting systems, and finally,
- agency and autonomy as a way to introduce unexpectedness.

This design space opens for and suggests various ways to work with playful mobile media applications that would be interesting and valuable to explore.
Chapter 4

Method

This chapter provides an overview of how the research in this thesis has been conducted. Although the two individual case studies have differed somewhat in the choice of methods, they still share an overall approach and research setting, which is presented here. Further details about each case are described in the following chapter presenting the case studies, as well as in the respective research papers I-IV.

Research Setting

The research in this thesis has been conducted at the Future Applications Lab (FAL) that was previously at the Viktoria Institute in Göteborg, Sweden, and is currently affiliated with the Mobile Life Centre in Stockholm. During the time this work was performed, FAL did multidisciplinary research within the mobile and ubiquitous computing domain with an focus on entertainment in the ‘mobile life’, and with an aim to explore novel technology that is likely to exist in everyday applications and devices in about five years in the future.

The starting point in FAL’s research has often been a new technology or technical concept, and additional influences are taken both from creative fields such as photography, music, and visual art, as well as from strong technical fields such as ubicomp and AI. Despite having a technical idea as a starting point, the research in FAL has often involved potential users throughout the design process – they have been involved early in the design process by providing inspiration (Holmquist, 2004; Ljungblad and Holmquist, 2007; Ljungblad, 2008); later by giving feedback on design based on hands-on experiences with prototypes; and finally, in user studies where they have reflected on what it means to use the prototypes in their everyday lives. This approach of involving potential users differs however from user-centred design in HCI and in participatory design (e.g. Ehn and Kyng, 1991) in that it uses people’s feedback and experiences as a source of inspiration, rather than requirements when setting the agenda and goals for design (Holmquist, 2004).

Overall Research Approach

The case studies in this thesis essentially involve the following phases, which are conducted in an iterative manner: conceptual design and framing of the design space; prototype design and implementation; testing with users; and analysis and reflection. The work embraces a knowledge-generating design-oriented research approach (Fallman, 2003) in which such
activities – from concept design to analysis – allow the researcher to gain knowledge about an initial question, idea or concept:

‘Design-oriented Research, what we see as the conduct of academic researchers, should have truth or knowledge of some sort as its main contribution, specifically such knowledge that would not have been attainable if design — the bringing forth of the research prototype — were not a vital part of the research process. … In design-oriented research, the knowledge that comes from studying the designed artifact in use or from the process of bringing the product into being is the contribution, while the resulting artifact is considered more a means than an end.’ (Fallman, 2003, p. 231)

As put forward by Fallman, prototypes are not the end goals in this research process – rather, they help the researcher obtain knowledge that otherwise would have been impossible or very difficult to get. They can be seen as ‘probes’ that help exploring a design space and bring to light certain aspects and dimensions of it. This is similar to how so-called ‘technology probes’ – deliberately simple and incomplete technologies that are introduced in the real world – can help designers, engineers and future users explore and think about the potentials, practices, and requirements of such technologies (Hutchinson et al., 2003). Within the iterative design process, the point is then not to strive for increasingly more advanced prototypes or optimal solutions, but to refine them in a way that allows the researcher to deepen the knowledge (Redström, 2001). Designing and implementing prototypes can also be an invaluable tool for communicating ideas within a research team, and with a research community at large, where they help bringing the conversation forward by illustrating a specific framing of a problem (Zimmerman et al., 2007).

Conceptual Design

The case studies in this thesis have thus all begun with some novel technology or technical concept as starting point. Based on the starting point and the design space, the activities in this phase are focused on mapping out different possible application ideas that could help investigating the design space, which obviously at the same time should be interesting and meaningful to users, as well as original from a research perspective. In many cases in HCI and CSCW, there are existing practices in which the new technology needs to be grounded, and which therefore – through activities such as ethnographic observations or other fieldwork – can inform the design process with insights and requirements. However, with the emergence of new technical innovations in for instance ubiquitous computing, researchers also face situations when these technical innovations create entirely new possibilities for practices that do not exist and have yet to emerge (Crabtree, 2004).

In this work, several different methods have been used to map out and explore different possible application ideas – both within the research team, and with groups of potential users and enthusiasts. Within the team we have conducted brainstorming sessions interweaved with other activities such as research literature reviews, reviews of technical possibilities, and hands-on
exploration of similar or related existing technology. However, we have also received invaluable input from groups of potential users in focus group sessions, brainstorming sessions, and qualitative interviews. As mentioned above, this input has not been translated into requirements, but has rather served as a source of inspiration. In the work on Context Photography, for instance, a group of amateur photographers met with us to discuss what values and experiences they think are important in their own photo practice, and based on that, reflected on our early idea of letting sensor-based environmental information be a part of a novel photographic device (Ljungblad, 2007).

Prototyping

In order to explore and take a design concept or application idea further, it becomes important to create representations and embodiments of it in terms of prototypes. Especially when there is no similar existing technology or practice, prototypes play a crucial role in deepening the understanding of a particular question or idea, and as technical proof of concepts they help the development process forward. In this thesis work, it has also been necessary to develop prototypes that are working and robust enough so that they can be handed out to participants in longer studies in everyday life, usually at the end of a design process.

Prototypes can be seen as ‘representations of a design made before final artifacts exist’ (Buchenau and Fulton Suri, 2000), and prototyping can be done at all levels in the design process from simple sketches, to paper models, to more complex implementations (Houde and Hill, 1997; Buchenau and Fulton Suri, 2000). Prototypes can assist in understanding user experiences and contexts in a new domain, help evaluating existing design ideas in a setting, and as mentioned, make it easier to communicate ideas both within a research team, and with others (Buchenau and Fulton Suri, 2000). As Houde and Hill (1997) argue, however, prototyping interactive systems can be challenging because of their complexity, which makes it difficult to create prototypes that entirely capture what one wants to explore or communicate. They therefore suggest thinking about what exactly a prototype should prototype – if it is for instance the role, the look and feel, or the implementation of an artefact – and then develop different prototypes depending on the purpose. As Holmquist (2005) further stresses, it is also crucial when presenting prototypes to others, users as well as other researchers, to be clear about its purpose. That is, prototypes should be seen and used as vehicles for communication – and hopefully become powerful generators of ideas – rather than representations of end products.

In the work on the Context Camera, for instance, three different prototype versions helped us explore the concept of Context Photography. The first one helped us explore the concept within the team as well as communicate it with amateur photographers in an early concept workshop; the second allowed a group of amateur photographers to interact, explore, take photographs and feedback on it in interaction workshops; and the third prototype that ran on mobile phones allowed users to explore it in their everyday life in a longer user study, which made it possible for us to learn
about how they used and understood it as a new photographic device. In the case study of Push!Music, a couple of small software experiments helped us try out different aspects of the concept before implementing a prototype for mobile devices. The Context Camera prototypes and the Push!Music system have further been demonstrated and exhibited numerous times to the HCI and ubicomp research community, industry, and the media (see e.g. Gaye et al., 2004; Jacobsson et al., 2005; Rost et al., 2005).

User Studies
The user studies in this thesis have been conducted in order to learn how the prototypes are used and experienced in everyday life, and reflected upon in a wider sense. They are therefore exploratory and qualitative in approach. The aim has not been to evaluate whether users have used or understood a prototype in a certain ‘correct’ way – rather, it has been to open for multiple meanings (Sengers and Gaver, 2006) and understand different possible uses and interpretations. Since the prototypes in this thesis are intended to be used in everyday life and interwoven with other activities, we argue that it is important to conduct the studies in everyday life settings as well, and preferably as long as possible. Although many researchers with us (e.g. Kjeldskov and Graham, 2003; Rogers et al., 2007) claim that it is crucial to conduct user studies of mobile and ubicomp technologies ‘in the wild’, it is still not standard. As demonstrated by Kjeldskov and Graham (2003), a minority of mobile systems and prototypes are actually tested after the implementation phase, and if they are, this is commonly done in lab settings, rather than with users in real-world settings.

Studying mobile technologies is however challenging in many ways, for instance because they can be used anywhere and anytime and not in a routine or planned way; they can be used in places that are not possible to get access to as researcher (Weilenmann, 2003); they might be used by many people at the same time; and they might even be used when moving in high speed (e.g. Esbjörnsson et al., 2004). Moreover, from a technical perspective, mobile and ubicomp prototypes might be unstable, fragile, and require frequent recharging of batteries and constant network access, which taken together poses challenges on methods, settings, researchers and the participants themselves. So even if it is preferred to run a study for a long time, sometimes the demands put on the participants – like remembering to recharge batteries several times a day – calls for compromises about the length of a study. When studying Push!Music, the design of the system put demands on setting and participants. To share music with the system, one needs to be within a range of approximately 100 meters from another user. This implied that an important condition was a setting where such encounters between users would be possible, preferably multiple times during the study.

In this thesis work, we have used a combination of quantitative and qualitative methods to gather data, with a strong focus on the latter. In terms of quantitative data, we have saved log data from the prototypes, which has provided complimentary information such as frequency and amount of use. In terms of qualitative data, we have mostly relied on post-study semi-
structured qualitative interviews (either in group or individually) where the participants have openly given and discussed their accounts of their experiences. In the study of the Context Camera where the participants were distributed worldwide, we used questionnaires instead. We also collected the participants’ context pictures, which apart from providing some quantitative data helped us analyse how they had used the camera together with their written accounts.

Other methods that would have been suitable include different types of self-reporting techniques such as diaries, video diaries, blogging, ‘experience clips’ (Sundström et al., 2007), etc. where the participants contribute with their accounts on a more regular basis throughout the study, and ethnographic observations (e.g. Hammersley and Atkinson, 1995), when possible to conduct with regards to setting and activity.

Analysis and Reflection

Analyses and reflections are done at all levels throughout the entire design process, but an important part takes place after a user study has been conducted. As mentioned, most studies in this thesis have been conducted using a combination of methods, and in the analysis phase, data from these methods are analysed together to provide complementary parts. All interviews and focus groups are recorded, and thereafter transcribed to facilitate analysis. Quantitative data such as log data and similar are presented in a more visible form to facilitate overview.

The analyses have consisted of familiarising with the data by reading it multiple times, then identifying noticeable events and subjects, and finally finding larger themes of events that have occurred in the study. At this point, existing theory about for instance social practices have helped gaining deeper understanding about occurrences in the data. The outcomes of the studies are primarily insights about design or implications for design, which are aimed at future design in the same and closely related areas. Together with the study, these insights are often communicated to the research community in research papers and other publications.
Chapter 5

Case Studies

The research presented in this thesis is mainly based on two extensive case studies – Context Photography and Push!Music – and the activities related to them. The case studies explore different parts of the design space of mobile media, play, aspects of the surrounding physical and social context, and agency and autonomy, and the two prototypes that have been designed, implemented and studied – the Context Camera and the Push!Music system – can be viewed as probes that help exploring it. This chapter will provide a presentation of each of the two cases, and how they both contribute to an increased understanding of the design space.

Further details about the work on Context Photography can be found in paper I, which presents an exploratory study of the Context Camera with users, and in paper II, which includes an in depth account of the entire design process. Details about the work on Push!Music can be found in paper III, which presents the system and results from a pilot study, and in paper IV, which mainly includes the results from a larger study with users.

Context Photography

The case study of Context Photography explores how sensor-based information about the immediate physical surroundings can be exploited as a resource in a digital photography application for everyday creative use. Rather than using such information to design a context-aware camera that would invisibly support the act of taking pictures or browsing them (e.g. Healey and Picard, 1998; Lockerd and Mueller, 2002; Holleis et al., 2005), the user here actively influences the aesthetics of the pictures with environmental information from sensors in real time. The case study looks at the interplay between users and environmental aspects of the surroundings, where both the user and the camera based on sensor data can take active roles in affecting the visual outcomes in digital images. Context Photography differs from sensor-based interactive art installations or performances (e.g. Bongers, 2000), which are often limited in space and time, and thus not for everyday use.

Designing the Concept of Context Photography

The work on Context Photography started in an initial interest in exploring what would happen if one added sensors to a digital camera and sensed aspects of the scene (others than light) to add something to the picture – to get a ‘bigger picture’. How could such sensor-based information be used in an interesting, sensible and aesthetic way? How could this become a new enjoyable photographic experience to users? After seeking inspiration in
different photography practices, we became acquainted with a local group of so-called lomographers who participated in developing the concept of Context Photography (Håkansson et al., 2003; Ljungblad et al., 2004; Ljungblad, 2007). Lomographers are amateur photographers devoted to a certain kind of analogue cameras that due to technical defects give rise to pictures with unexpected visual qualities and particular aesthetics. They promote always bringing one’s camera to be ready for spontaneous picture taking, and not planning much in advance. Lomographers have an exploratory and humorous approach to photography that embraces mistakes and serendipity, which we felt could be a valuable source of inspiration for the development of a novel playful photography concept. Their contribution to the forming of the concept was significant, for example by pointing at the potential in letting aspects of context affect the visuals in an image in an intriguing way, rather than using them to support taking better photos, or presenting them as an informative ‘report’ of the surroundings. Furthermore, they emphasised the fun of the unexpected when taking pictures and the importance of having room to be able to create one’s unique personal expression, along with some degree of control over the outcome. Learning about the lomographers’ attitude also directed the project’s focus on everyday creativity. Everyday creativity, as we see it, can mean all kinds of creative activities that take place spontaneously in the everyday, triggered by whatever happens to exist around the person in that moment. It is something that anyone can do and enjoy at anytime, which distinguishes it from professional or planned activities with specific purposes. The group of lomographers and other amateur photographers participated early in a design workshop where the panel reflected on our concept (Håkansson et al., 2003), and later in two evaluation workshops where they tested an early version of the Context Camera prototype in specific settings (Ljungblad et al., 2004).

The concept of Context Photography consists of taking photos that capture not only incoming light but also additional aspects of the surrounding scene, and letting them visually affect the pictures in real time as they are taken. Rather than providing any explanation of what the visual effects mean or how they should be interpreted, this is part of the user’s own exploration, interpretation and appropriation.

Foregrouding Aspects of Context

In the work on Context Photography, we explore the foregrounding of context as an approach to making sensor-based information a resource available at hand for users to interact with (see paper II). By ‘foregrounding’ we mean in this case making it ‘visible’ to users. As mentioned previously in this thesis, we refer here to sensor-based information, and in the case of Context Photography, specifically to environmental information. The approach of foregrounding context is similar to the idea of seamfulness (Barkhuus et al., 2005), where network ‘seams’ are made visible to pervasive gaming participants as a real-time resource in playing the game. We argue that the way sensor-based information about the surroundings is usually processed

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in the background of context-aware systems to allow pro-active support might not be suitable for creative practices; similarly to how it is not suitable in other application areas like learning practices where engagement is also crucial (Rogers, 2006). Dealing with information in such a way in creative applications would promote a passive relation between the user and the everyday world that the sensors would otherwise open to. This would potentially impair users’ sense of creative engagement in the use of the system. Consider as an example modern ‘smart’ digital cameras that do not allow the user to take a blurry picture, even if the person wants to. We propose instead that the user should be able to consciously engage in the use of sensor data, and believe that foregrounding it is one promising way to do it.

Figure 1. The final Context Camera application on mobile phones.

The Context Camera

The Context Camera prototype is a digital still camera application that uses sensor-based information – movement and sound – from the immediate surroundings to visually affect images in real time. With the Context Camera, users can for instance take a picture of a busy road and get certain visual effects in the image that would look different, had it been taken in the same setting but on a quiet occasion. The final prototype runs on standard cameraphone models (see Figure 1) and uses the phone’s built-in camera and microphone to sense movement and sound respectively (Rost et al., 2005). The data from the sensors is mapped in real time to a set of four visual effect combinations, which each consists of one sound and one movement parameter that in different ways affect the pictures (see visual examples below). The visual effect combinations are:

1. **Colour shadows**: Traces of coloured shadows follow movement; the colour of the shadows is affected by the frequency of the surrounding sounds (see Figure 2a-c)
2. **Zoom:** The part of the picture with most movement is zoomed in, and rendered as a transparent layer on top of the rest of the image; the amount of transparency is determined by surrounding sound level (see Figure 2d-f)

3. **Pixel:** Small white dots follow movement as a decaying trace; the size of the pixels in the picture is proportional to the surrounding sound level (see Figure 2g-i)

4. **Wave:** Movement creates waves in the image, making it look like a dense liquid. The size of the pixels in the picture is proportional to the surrounding sound level (see Figure 2j-l)

![Figure 2](image)

Figure 2. A selection of context pictures taken by users in the study. From top to bottom: 2(a-c) are examples of visual effect 1 (colour shadows), 2(d-f) are examples of visual effect 2 (zoom), 2(g-i) are examples of visual effect 3 (pixel), and 2(j-l) are examples of visual effect 4 (wave).

The user can easily switch between the effect combinations. The visual effects become visible after the user has taken an image, and each context photo is saved along with a copy without visual effects. The sensibility of the sensors can be calibrated according to the user’s own perception of the situation, or simply according to taste: he or she can decide how much of the sensor data should influence the pictures, or even turn off the visual effects
from one or both sensors. The Context Camera can thus be used as a regular camera if one wishes.

**Studying the Context Camera**

In order to get an understanding of how people would use and experience the Context Camera, we conducted an exploratory user study after the design process had ended. This study was not an evaluation of the concept or the prototype in terms of deciding whether users used it or understood it in a certain ‘correct’ way. Our aim was rather to open for multiple meanings (Sengers and Gaver, 2006) and understand different uses of the Context Camera through the users’ subjective experiences and context pictures.

The study ran for six weeks and involved seven people with a general interest in photography who used the Context Camera in their everyday life. They had replied to calls for participation that were sent out to blogs, mailing lists, and our project website, and the group happened to be diverse in terms of age, gender, occupation and nationality. The participants either used their own phones, on which they installed the application, or borrowed one from us. They were only given instructions on how the Context Camera functioned technically, and received no tasks or instructions on what to take pictures of or how.

We collected a total of 303 context pictures during the study, which the participants either made available to us on the photo sharing site Flickr\(^\text{10}\), or e-mailed directly to us (for a sample, see Figure 2). The participants replied to a mid-study and a post-study questionnaire where they were asked to describe their overall interest in photography, and in particular, describe and reflect upon their use and experiences of the Context Camera. Several questions encouraged them to refer to context pictures they had taken. Two participants were locals and were therefore interviewed at the end of the study, but they were asked the same questions as in the distributed questionnaires.

The analysis both consisted of analysing each participant’s individual experiences together with his or her pictures (detailed in paper I), and of drawing more collective findings about what it implies to let environmental sensor data visually affect pictures in real time. We learned that Context Photography gave rise to new photographic experiences, and implied new types of goals, expectations, aesthetic considerations and practice of taking pictures.

Briefly, in terms of goals and motivations of taking context pictures, our study showed that the participants had at least two different goals: either trying to explicitly ‘capture’ aspects of a setting, like the sound of seagulls when sailing in the archipelago, and ‘represent’ it in a picture; or using movement and sound as new parameters that affect the outcome, where the surroundings through the camera application could be seen as a ‘contributor’ to the picture. In terms of expectations, we learned that Context

\(^{10}\) Flickr. http://www.flickr.com/ (accessed 14-12-08)
Camera users expected to get visual effects in the pictures, and that they would look upon them as uninteresting and boring without effects, even if the pictures happened to be taken in still and quiet settings that would not produce any effects according to the mapping. In terms of aesthetic considerations, we learned that aesthetics is very subjective and it is not possible to summarise how the participants preferred their pictures. However, for all users, the context images need to reach a balance in the amount of visual effects in order to possess an aesthetic value. Finally, in terms of picture taking practices, the study revealed that several participants used the Context Camera as an ‘action camera’, actively seeking or creating sound and movement to get interesting effects. It also showed that some users thought it was exciting and fun to not always be in control of the picture taking due to the dynamic nature of the input.

Design Opportunities and Challenges
The foregrounding of aspects of context brought up both design opportunities and challenges in terms of mapping the digital and physical worlds. For instance, in what visual form should the information be foregrounded and how should changing sensor values affect the outcome? How could dynamic information like movement and sound be represented in a static medium like still images? Furthermore, we wished to design a camera that would be a creative tool for amateur photographers that would be fun, engaging, and suitable for everyday use and with which users would be able to take aesthetically pleasing photographs. How could the camera encourage exploration and creative activities? Several design decisions were made regarding the choice of sensors, mapping, visual effects and real-time interaction that strongly influenced the use of the Context Camera in the study. A number of them are introduced below, along with insights gained during the process of designing, implementing and studying the Context Camera (for further details, see paper I and II).

Designing with Aspects of Context
This section describes insights related to how aspects of context were managed in the Context Camera. We wanted to represent environmental sensor-based information in real time with visual effects, which was a fundamental challenge as we did not know how sound and movement could be represented in a still image, and yet allow for playful and creative exploration. We experimented with different representations together with an interactive media artist, and visual effects of sound and movement were eventually combined based on how well they would fit together aesthetically, and how well we felt they would represent various settings together. That is, it was important that an ‘extreme’ setting of lots of noise and movements did not render the image completely unrecognisable. We further aimed at making the effects ambiguous enough (e.g. aesthetic as opposed to directly ‘readable’) to be open for users to interpret them subjectively, since ‘ambiguous situations require people to participate in making meaning’ (Gaver et al., 2003, p. 235). Since the Context Camera is meant for everyday use, we wished to make it engaging even in the long term. This does not necessarily suggest that it should be used on a regular basis, but
that it should be exciting for many diverse occasions, as well as for both new and more experienced users. We therefore experimented with designing more complex mappings in order to increase the level of user effort in taking satisfying pictures. These design decisions led to the following insights:

Representing sensor data with visual effects changed users’ view of what a successful context picture is, which also influenced their strategies when taking context pictures. In the study, new goals and aesthetics emerged when taking context pictures, where the users expected to obtain visual effects in the pictures. A picture that turned out like a regular photo without visual effects, due to a quiet and calm setting, was considered boring and not a good example of Context Photography. Therefore, as one person explained regarding trying to get visual effects: ‘you are forced to be creative to get pictures. If you don’t do anything then it’s like a regular camera.’

Because of the ambiguous visual effects, the participants did participate in making meaning of Context Photography and context pictures in the study. They talked about pictures in diverse terms like being ‘reminiscent of a painting’, having a ‘sense of rhythm and complexity’, ‘it looks like you were sitting in an amplifier’, ‘one can imagine the sound of screaming’, and ‘I like this one because it isn’t at all clear what is being photographed’. Since the Context Camera is an application meant for creative purposes, we learnt that we needed to reduce as much as possible any pre-designed feeling of the effects, and let the effects change more dynamically to changing sensor data. Together with ambiguity, this gave more room for users to create their own personal expressions as well as interpretation of what a context photo means or represents, if anything.

The aesthetics of context pictures was more important to users than any ‘correct’ use and mapping of the sensor based information. That is, participants were more concerned with taking aesthetically pleasing and interesting pictures, rather than ‘capturing’ or ‘representing’ a situation in a ‘correct’ way. Importantly, the visual effects should be balanced and not override the subject of the original scene.

The ‘here and now’ aspect of the real-time interaction was a very important part of the overall user experience with the Context Camera. Restricting the interaction to what was possible and present only in the current moment resulted in that some participants argued that it made it frustrating and limited in comparison to visually manipulating pictures afterwards, e.g. in Photoshop. However, several other participants claimed that the real-time interaction contributed to making Context Photography unique, exciting and challenging in a positive way. Experiencing how the visual qualities of images directly resulted from the situation created a strong connection to the original place and time in which the pictures were taken, as one participant put it: ‘In some way it feels more real. I did not manipulate this picture afterwards, this is how it WAS…’

Making the mapping more complex, requiring more effort when taking pictures, seemed to result in more room for exploration when using the
camera. In the beginning of the design process, we learned that workshop users felt it was too effortless to get nice-looking pictures with an early version of the Context Camera. They valued effort in the creative process and thought that easiness was somewhat equivalent to cheating. In Hunt et al.'s research (2002) about mapping strategies in alternative music controllers, results show that simple mappings are less stimulating in the long run than complex ones. In this case, complex mappings are more interesting because they provide a more stimulating challenge and require more effort to master. Using this idea in Context Photography, we thus experimented with designing more complex mappings in order to increase the level of user effort in taking satisfying pictures. As Graves Petersen et al. (2004, p. 274) argue regarding designing for ‘aesthetic interaction’, the ‘ideal appropriation of technology is not the shortest way to mastery (as proposed by the tool perspective) but rather the process of appropriation itself becomes essential.’ Similarly, we learned that making room for exploration that requires some effort instead of providing the simplest way was important in the Context Camera.

**Combining Explicit and Implicit Interaction**

This section describes insights related to how users used and experienced aspects of context in the interaction with the Context Camera. Usually, sensors are specifically assigned to enable either explicit or implicit interaction, depending on the modalities of the application (Rogers and Muller, 2005). We made no such distinction in the Context Camera, which left it open for users to explore and decide for themselves how they wanted to interact. For instance, the microphone sensed and reacted to sound regardless of the source: a user directly screaming into the microphone to affect it, or the ambient noise from a street where the user happened to be. This also gave the Context Camera some degree of agency to autonomously affect pictures, based on sensor data and the graphics programme. It implied that even if a user did not actively influence the camera, it would still autonomously sense the sound and movement around it and map this to visual effects according to the defined rules. These design decisions led to the following insights:

A key insight is that taking in aspects of the surrounding physical context provided opportunities for both *explicit and implicit interaction*, and that the combination of them proved to be very valuable to the overall user experience. An interrelated insight concerning the Context Camera as a creative tool is that it was important to reach a balance between explicit and implicit interaction. We will explain below what results this had on the use and experience of the Context Camera.

When exploring the camera, participants on the one hand *explicitly and actively interacted* to create input to affect images. Allowing for explicit interaction gave some control to the user, made it possible to develop skills, be creative, and find a personal expression. A number of design decisions shaped the explicit interaction – essentially, what we chose to foreground strongly affected how the users interacted with the camera and what they looked for and explored in their immediate surroundings. One insight is
therefore that the framing of the interaction and the foregrounding of aspects of context need to be carefully designed. We opted for dynamic aspects of the environment such as movement and sound, and real-time image manipulation based on the sensor data. These decisions resulted in quick and spontaneous interaction that both made it possible for the users to immediately see the results of his/her actions and thereby learn how to use the camera, and to take a number of different-looking pictures in a short time. Other kinds of information, for instance temperature that is changing more slowly over time, would most likely have created a completely different experience and interaction with the camera.

Foregrounding sound and movement made several users actively search for it or create it themselves, which point at an increased awareness of these aspects of the surroundings. They used the camera as an ‘action camera’ in busy traffic situations, in a theme park, when playing an instrument, etc., and took pictures of moving objects and people who were running, diving, screaming, twirling a flower, driving, etc. One participant told us that when using the camera he focused a lot on sound and movement in his environment and was searching for sources or opportunities to take intriguing pictures, which ‘rendered a new and interesting experience and results.’ Another user said: ‘I would probably never have spontaneously taken a picture for example of a car passing by if it hadn’t been for the effects that the application gives.’

The mapping and the default values were also important when framing the interaction. Since the mapping is designed so that visual effects are attained only when there is input in terms of sound and movements, Context Camera users were encouraged to be physically active or search for busy settings in order to get visual effects. Had the mapping and values been set to the opposite, then users might have been encouraged to be completely still and quiet to get a picture with a certain effect.

Other ways of interacting explicitly included switching between visual effects to find one that suited a setting, as well as calibrating the sensitivity of the sensors, or simply turn one of them off to concentrate on exploring the other. We believe that the calibration function offered an important possibility for users to affect the balance between the explicit interaction, and the implicit interaction, as we will turn to next.

On the other hand, the participants also implicitly interacted with the camera, for instance by searching for or simply being in a setting with certain properties that implicitly affected the images. The implicit interaction with the camera – and the capacity of the camera as an autonomous ‘co-creator’ – embraced the dynamic, unexpected, serendipitous, and spontaneous qualities of the surrounding environment. Rather than seeing the camera as autonomous, however, users looked upon this as if the situation or setting was playing a role in deciding how the image would look. As one person said: ‘much of the fun with context photography is that you feel you are not entirely in control over how the picture will turn out. The situation will determine this...’
Another user said: ‘you have to see it like depending on where you are, the picture turns out cool.’

Many of the pictures were in fact taken in dynamic settings like in a theme park and urban spaces. One participant started to learn how the camera worked after she had brought it to a ‘very noisy workshop’, and she continued using it in noisy environments. Some participants did take pictures in quiet and calm settings as well, such as during a walk with the dogs in the countryside, but referred to these pictures as dull because nothing was happening in them. As mentioned above, some argued that not always being in control and leaving it open for the situation to influence some parts of the picture, added to the excitement of taking pictures with the Context Camera. Others thought it made the picture taking become more of a ‘fluke’, rather than depending only on the skill and creativity of the photographer. As one participant seemed to suggest, the possibility of fluke made it more difficult to rely on her own skill at taking good pictures.

In the study, the combination of explicit and implicit interaction resulted in the participants giving the foregrounded sensor-based information – and thus essentially the camera in some cases – several interchangeable roles: pictures can be taken of the information as a subject, with the information as a passive contributor and/or by the information as an active contributor. Context photographs were thus shaped by both users and the camera based on input from the physical surroundings. Users were physically engaged in making creative and spontaneous use of their surroundings and other means at hand, as well as calibrating how much the surrounding sounds and movements would influence the picture, while leaving room for chance and creative accidents.

**Push!Music**

The case study of Push!Music explores how co-located connected users together with so-called ‘media context’ on mobile devices can be exploited in a mobile music sharing and recommender system to allow for playful and inspirational experiences with music. It looks at the interplay between users who happen to be physically close to each other, and the music on their mobile devices – where both the user and the songs actively contribute to shaping the user experience of mobile music sharing. The media context will be described in more detail below, but in this work, it refers essentially to the context – in a playlist on the device – in which songs are played and managed.

The work on Push!Music thus focuses on mobile music sharing between people who are in the vicinity of each other and how we can design for providing new music influences among them. Online music sharing practices have existed for a long time (Brown et al., 2001) and there are a number of online music recommender systems (e.g. Pandora11) as well as

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music-oriented social networks (e.g. Last.fm\textsuperscript{12}), which help us share or explore new music when sitting in front of our computer, but there are less opportunities for the mobile life. Two research projects – tunA (Bassoli et al., 2006) and SoundPryer (Östergren and Juhlin, 2006) – are exceptions and early examples of how music could be shared when on the move by allowing music to be streamed between mobile devices and car stereos respectively. A commercial example, Zune\textsuperscript{13}, allows copies of songs to be manually sent between devices. The work on Push!Music builds upon tunA and SoundPryer in that it makes use of ad-hoc peer-to-peer networking to facilitate music sharing, but it differs in several other way as will be described further below.

**Designing the Concept of Push!Music**

With Push!Music we wanted to explore ad hoc peer-to-peer music sharing and what would happen if mobile MP3-players could ‘learn’ about different users’ listening habits and spontaneously introduce new music based on local people’s shared music interest. Initial ideas suggested making MP3-files ‘smart’ and letting them do the sharing themselves – thus letting music find listeners instead of the other way around. In order not to send just any random song to another player, songs would need to have some knowledge about themselves and based on that knowledge, ‘know’ whether they should copy and transfer to a nearby device, or not. We therefore explored how ordinary MP3-files could be turned into so-called ‘media agents’ (Håkansson et al., 2005; Jacobsson et al., 2005; Jacobsson et al., 2006) that would involve adding sensing, history, rules, and behaviour to MP3-files, which could then allow songs to autonomously move between mobile devices. Each media agent is a software agent (Maes, 1996; Shneiderman and Maes, 1997), which is a software entity that senses the environment it is in and acts on information according to its own agenda.

Based on the ideas above, the *initial concept of Push!Music* involved a mobile music application where songs (media agents) could autonomously move between nearby devices based on the users’ shared listening habits to add spontaneous and even provocative music recommendations. However, previous research has emphasised the important role of friends when sharing and recommending music. Many practices related to music consumption, creation and sharing are very social, and friends are particularly important sources when it comes to discovering new music (Brown et al., 2001; Håkansson et al., 2005). Existing research on social music practices (e.g. DeNora, 2000; Brown et al., 2001), design of recommender systems (Swearingen and Singha, 2002) and our own small qualitative interview study of music sharing practices (Håkansson et al., 2005) stressed the importance of allowing users to personally send and recommend songs as well.

The *final concept of Push!Music* therefore included a personal manual way of sending songs directly to other nearby users, besides the autonomous

\textsuperscript{12} Last.fm. http://www.lastfm.se/ (accessed 14-12-08)
\textsuperscript{13} Zune. http://www.zune.net (accessed 14-12-08)
sharing of songs. As a result, every identified and connected user in the proximity would be made visible in the application and thereafter also possible to manually send music to. The overall design criteria of the Push!Music system came to be: a mobile music player that would let songs autonomously copy themselves between devices based on media context to spontaneously recommend new music to users; allow users to send songs directly to other connected users; and that would display connected users in real-time.

Figure 3. The Push!Music system.

The Push!Music System

Push!Music is a mobile music player with ad hoc wireless sharing capabilities that allows music to be shared between users who are in the vicinity of each other (Jacobsson et al., 2005). It runs on PDAs with wireless networking (WiFi), see Figure 3. At the time of the development, standard mobile phones had not yet been equipped with WiFi, but current more advanced mobile phones like the iPhone\(^{14}\) would obviously have been an optimal choice of platform. When used for listening, Push!Music works as an ordinary MP3-player with standard controls. In contrast to tunA (Bassoli et al., 2006) and SoundPryer (Östergren and Juhlin, 2006) where the music is streamed – either initiated when a user selects a song to hear in another user’s playlist in tunA, or automatically when two cars encounter each other in SoundPryer – the music in Push!Music is copied between devices. Songs can therefore spread in a social network of music listeners as more people carry them. Another difference is that in Push!Music, songs can be sent to other people both manually and autonomously, as described next.

The system allows two ways of sharing music as soon as another user is anywhere within the WiFi range of a Push!Music device and thus connected in an ad hoc manner. First, songs can autonomously copy and recommend themselves to connected users based on a similar media context. Second, users can manually ‘push’ (send) songs as personal recommendations to

\(^{14}\) Apple iPhone. http://www.apple.com/iphone/ (accessed 14-12-08)
connected users in the vicinity. A transfer takes about 20 seconds, and whenever a new song is transferred to another device, it is placed in a temporary pool of incoming music. After the current song has finished playing, the songs from the pool are automatically played one after the other in the playlist. While a song is playing, a history list of the most recent ‘owners’ of this song is displayed in the interface. The interface provides a number of different views, where the user can switch between seeing the playlist, a list of currently connected users, an activity list of ongoing song transfers, the temporary pool of received songs, and finally, the user’s music library on the device (see Figure 4).

Co-located and connected users are displayed in real time in a list in the interface. Push!Music was deliberately designed as an open system with few limitations: all other users who happen to be nearby will appear in the list, and there are no restrictions with whom you could share music – if someone pushes you a song, it will end up in the your playlist. On the one hand, we wanted to explore in studies how users would use and make sense of such an open system, and on the other hand, leaving it open would also make it possible for novel and unexpected kinds of mobile music sharing. The displayed information about users is minimal and rather vague: users select a personal nickname, but there are no pictures, and no further information about how long users have been connected, or where within the WiFi-range they are located. The activity list also shows whether a recommendation of a song is autonomously or manually initiated, and between whom a transfer is done.

The media context is gathered implicitly in the background of the system, as the user is listening to and managing music in the interface. We wanted the user to be able to listen to music in an ordinary way without having to be directly affected by the accumulation of media context. More specifically it is the media agents that gather the media context. As mentioned, a media agent is an MP3-file that is augmented to constantly collect and accumulate information about the songs it is being played with, that is, the media context it exists in. For instance, each media agent knows from the media context if it has been played, if it has been rated and what rating it has, what other songs it is being played with and what rating those ‘neighbouring’ songs have, and if it has been sent as recommendation to another player. We further use concepts similar to collaborative filtering to create a distributed recommender system (Jacobsson et al., 2006), where agents are triggered to copy themselves to other devices in the vicinity where they would fit in according to the media context. Each agent thus uses the media context to

Figure 4. The Push!Music interface.
compare itself with songs on other devices. If the conditions on another device are satisfactory, the song autonomously starts copying itself to the new device. This happens primarily with other nearby players that have a similar listening history, but not already a copy of this particular song. As the agents carry their information with them, they accumulate the amount of data as they visit new devices and are thus able to make better and better predictions about which user will appreciate a song.

**Studying the Push!Music System**

In order to get an understanding of how people would use and experience the Push!Music system, we conducted two consecutive exploratory studies with users in everyday life settings where they used the system as a part of their ordinary life. Since the system requires both accumulating media context and other co-located users to allow for spontaneous music recommendations, it was crucial to conduct the studies with users in real world settings to learn about its qualities in use.

The studies were similar in set-up and performance. In both studies, the participants each borrowed a PDA with Push!Music installed and an initial set of songs that they had personally selected. They were encouraged to use Push!Music as they pleased during the study, but agreed to not change the music collection on their devices. Log data was saved on each PDA to provide a complementary picture of how each participant had used Push!Music. Since we needed a study setting that would support spontaneous ad-hoc sharing to happen between users, we chose a small university campus for both studies. Here people would be able to encounter each other on more or less a daily basis, and even meet on the public transport to and from the campus. During the studies we regularly met up with the participants for brief feedback and support sessions to check if any technical problems had occurred. At the same time we documented spontaneous comments and our own observations. After each study, we conducted semi-structured group interviews where the participants openly discussed their experiences of using Push!Music.

The two studies had different aims. The first study ran for two weeks and involved five friends who socialised daily at the campus. The aim of this study was twofold. First, we wanted to see how a group of users would collaboratively use the system, and in particular how they would experience the autonomous sharing of songs. However, we did not wish to evaluate the correctness of the autonomous recommendations, but rather how they would make sense of such a novel way of sharing music. Second, we wanted to see how the system functioned technically, and in particular the autonomous recommendations based on media agents. The second study ran for three weeks and involved 13 participants in the same setting. This time the primary aim was to explore how people would use Push!Music to share music with both acquainted and unacquainted co-located people. Therefore, we recruited some participants who knew each other beforehand, and some who did not know anyone else, and we were careful not to reveal the identities of the participants during the study.
In brief, the findings showed that Push!Music triggered social interaction between groups of friends in both studies, and that they used it as much for social play as for sharing and listening. For instance, they used it to perform pranks, to send songs as in-jokes, and to simply ‘game’ the system in order to explore how the sharing worked. The findings also revealed that received songs can be looked upon as gifts, and that the participants highly valued receiving new music when using Push!Music. The autonomous recommendations worked only in the first study because of technical problems in the second one, but when received, they were highly appreciated by the participants who thought that they were unexpected, fun, and did not require any effort from the receiver. Also, they diminished the responsibility and accountability of the sender, which most participants appreciated with regards to sharing with unacquainted users. Social awareness played a very important role in the second study, where the participants kept track of other users, and developed theories and guesses of who the other users could be. The two studies also showed that the participants shared music differently depending on whether the receiver was a friend or an unknown user. In general, they were active with friends and more passive towards unknown users, which involved observing others in the interface and relying upon the media agents to autonomously share themselves, rather than manually share songs.

Design Opportunities and Challenges
Facilitating music sharing between co-located users together with the so-called media context revealed both interesting opportunities and challenges for design. This became particularly evident in the two studies of Push!Music. Insights gained during the process of designing, implementing and studying Push!Music are presented below and for further details, see paper III and IV.

Designing with Aspects of Context
This section describes a number of insights related to how aspects of context were managed in Push!Music. In the system, co-located users were represented in real time with personally selected nicknames, and the participants picked names that ranged from their real first name, to more imaginative ones like ‘Hans’ (‘Hansel’) and ‘Greta’ (‘Gretchen’) (who were both female participants), and ‘Blixten’ (meaning ‘The Lightning’). The media context was gathered and managed invisibly in the background and became visible only through the result of using it, that is, the autonomously shared songs. These design decisions led to the following insights:

Displaying connected users allowed for social awareness, which proved to be more important than imagined, and had a great value in itself. The participants were clearly curious and wanted to see who else was connected. For some, checking for other users became an ordinary part of playing music in Push!Music. The displayed user information also made it possible to gain an enhanced digital awareness of people nearby who were not visible. The curiosity was most evident in the second study that involved both ‘friends and strangers’. According to the participants, it was intriguing when other
unknown users were around, and this triggered discussions and making guesses about who the other persons could be based on nicknames and people in the campus building. However, despite the large curiosity, there was no face-to-face interaction between unacquainted participants who did not know each other before the studies.

Making the social context visible with nicknames revealed tensions about identity. According to Juhlin and Östergren (2006), it is of great importance to think of the duration of an encounter between users and the disclosure of personal information, when designing mobile meeting support systems such as SoundPryer (Östergren and Juhlin, 2006), tunA (Bassoli et al., 2006) and Push!Music. Drawing upon social theory, they argue that the ‘temporality of the meeting is an important aspect when participants decide what to keep to themselves and what to reveal’ (Juhlin and Östergren, 2006, p. 78). Essentially, people do not want to disclose personal information that they could be held accountable for during, or after, an encounter with unacquainted people. People are particularly sensitive about ‘prolonged’ encounters with strangers such as spending considerable amount of time at the same café, because such encounters in combination with shared personal information could potentially cause embarrassing and awkward moments, and accountability. According to Juhlin and Östergren’s categorisation of mobile meeting support systems, Push!Music falls into a so-called cloaked category, which means that it is possible for users to keep their identities secret when encountering strangers. Since little information is shared in cloaked meeting support systems they support both ‘prolonged’ and ‘brief’ encounters between unacquainted people, as well as between friends since they can recognise each other outside of the system. However, what is significant in Push!Music, and what makes it different compared to other similar mobile meeting support systems, is that a part of the sharing is triggered and performed autonomously by the media agents. The participants felt comfortable sharing autonomously with unacquainted people and even appreciated it very much in the system. An important reason for this, as we will return to, was that the autonomous sharing diminished the participants’ responsibility and accountability.

For the majority of the participants, the vague identities of Push!Music users added to the excitement, as well as made the sharing more ‘unprejudiced’ and thus spontaneous. They argued that when one does not know what the receiver looks like, it is easier to just spontaneously send a song instead of worrying about what the receiver might think about it. In line with Juhlin and Östergren’s (2006) arguments above, some made clear that they did not want to talk to other users, and were therefore content about disclosing only impersonal nicknames. However, a few users, who took music sharing more seriously, became frustrated and would have wanted more information to be able to get in touch with the person to discuss music properly and possibly exchange more.

The autonomous sharing allowed a novel and unexpected kind of music sharing, yet it remained rather ambiguous to users what affected the songs to recommend themselves. This is not very surprising since the system
needs to gather media context for some time to make better predictions, and it is even likely that the recommendations in the first study were close to random. However, the participants eventually seem to care little of how similar the autonomous recommendations were to their own music – they were simply thrilled to receive music spontaneously in a ‘magical’ way. We will return below to how some of the participants ‘gamed’ the system in order to explore the autonomous sharing.

Combining Explicit and Implicit Interaction

This section describes insights related to how users used and experienced aspects of context in the interaction with Push!Music. Providing users with both manual and autonomous sharing possibilities led to a combination of explicit and implicit interaction, based on the surrounding social context together with the media context. Just like in the Context Camera, this left it open for users to explore and decide for themselves how they wanted to interact, and the combination proved to be very valuable to the overall user experience. We will describe the two ways of interacting with Push!Music below, along with the gained insights.

In Push!Music, the explicit interaction refers mainly to the ways participants actively and manually shared songs with other users, which was strongly influenced by the fact that the sharing was only possible between co-located people. As we will see, the explicit interaction allowed users to playfully explore the sharing possibilities and develop social practices related to Push!Music, and in some ways, manage their impressions to other people with music.

The possibility to share only with other co-located users made the music sharing in Push!Music very direct and personal between participants who were already acquainted. Sharing with nearby friends opened for ways of socialising that created a sense of social cohesion. Groups of friends used the system together to discuss and collaboratively monitor what was happening, send songs as in-jokes and use Push!Music to perform pranks on each other. For instance, this involved playfully sending songs to friends that one knew the friends would not appreciate. The manual sharing in Push!Music also offered a way to manage one’s impressions given to friends, where users sent carefully selected songs to others that they thought conveyed something particular about themselves. Impression management, as discussed by Goffman (1959), is the process we engage in when we consciously or unconsciously try to control what impressions others form about ourselves. As Voida et al. (2005) observed in a study of iTunes\(^\text{15}\), impression management is also performed in music listening and sharing practices.

Sharing with only co-located people obviously limited the sharing to here and now. Some users felt this was limiting, because co-located people are clearly not always the ones one would want to share music with. However, sharing only with co-located people opened for new experiences as well. The

\(^{15}\) iTunes. http://www.apple.com/itunes/overview/ (accessed 14-12-08)
majority of users thought that the system offered an intriguing, fun and personal way of sharing music. For example, one participant was very intrigued of what was going on around her, and she explained:

‘It was more fun, I think, to have them [other users] ‘live’, because knowing that someone is nearby but you don’t know who it is, that’s more exciting! Then it’s a physical person, not just a name on a display…’

The participants enjoyed Push!Music the most when ‘things were happening’, that is, when other people were nearby who would trigger interaction to happen. A critical mass of users is obviously important when the interaction is limited to here and now, which is not unique to Push!Music. However, without others around, it was just an ordinary music player and thereby less interesting. As one person explained:

‘If we all were there at school and listened to music then things were happening in the playlist... kind of unexpected things... some song from someone appeared... then things were really happening in the playlist... but... if you are at home, on the bus and don’t have any of the others around, well, then it’s kind of “oh, now THEY [the same songs] come again...”’

Sharing only here and now sometimes made it difficult to play according to the ‘rules’ or expectations of sharing and of ‘gift-giving’. Drawing upon a previous study of gift-giving practices with text messages (Taylor and Harper, 2002), the sharing of songs in Push!Music can be seen as exchanging gifts. This brings with it ‘rules’ about how to share with others, including an unspoken obligation to reciprocate to a received gift. Users thus sometimes felt obliged to reciprocate to people from whom they had received music, and this became particularly problematic with unacquainted people. In Push!Music, as soon as a person had moved out of the WiFi range it was no longer possible to reciprocate, which some participants thought was very frustrating since there was no guarantee that they would encounter each other again. The fact that Push!Music did not provide any way in the system to contact other users made this even more problematic. With friends one could reciprocate later or simply thank them face-to-face, but with unacquainted users the participants just had to hope they would encounter each other again.

The lack of feedback channels in Push!Music was a reason why a few participants did not enjoy the explicit sharing of songs to unknown users. They claimed that it is a fundamental part of the sharing to get to know afterwards what the recipient thought of the received song, and if there is no straightforward way of communicating this, they felt that the manual sharing lost its meaning. This also made it more difficult overall for them to express themselves and demonstrate their interest, identity, and knowledge in music, which made them less enthusiastic about manually sharing music. As one person stated:

‘I want credit [for sharing music], yes, you want something. If it [the system] grows and gets really big I think you... the motivation to push music you
don’t know [...] then it’s only interesting if you could perhaps build up some kind of reputation for pushing a lot of files or something…”

Using Push!Music revealed tensions related to sharing with co-located unknown users, and what social ‘rules’ there are when using such a system. One issue that was much reflected upon was whether it is socially accepted to send a song to an unacquainted person. Some users thought it might be considered too intrusive, whereas others claimed that Push!Music is just for fun and the sharing therefore is not intrusive. The participants had different motivations for manually sending songs to unacquainted people: as implicit requests for songs to be sent back; as a way to acknowledge other persons that they were nearby and trigger contact; or as a way to disseminate songs they liked.

Apart from the explicit interaction, Push!Music also opened for *implicit interaction* through the autonomous sharing triggered by the media agents using media context. It implied that not only users decided what songs to share, but also songs themselves. Push!Music had become a ‘co-sender’ when sharing music. The fact that each song had been given agency and could autonomously share itself to nearby users based on a similar listening history, strongly affected how the participants used the system, and how they reflected upon it. For users, the implicit interaction with Push!Music embraced an unexpected, intriguing, and ‘magical’ way of sharing music with others that did not require effort, and importantly, did not hold users socially accountable for sending songs.

Because it was ambiguous why certain songs autonomously recommended themselves, participants developed strategies and theories to explore how the system worked. In both studies we told them that songs could move automatically depending on how they listened to and rated songs, but left out details about how and instructions on what to do. In the first study, the group of friends playfully ‘gamed’ the system to see what happened in order to develop a comprehension of how it affected the autonomous sharing. As one of the participants suggested: ‘When I rate songs that I have received, things start to happen.’ Another user described how he tried to be tactical when listening to songs to affect what songs would eventually share themselves:

‘Well, I tried to rate tactically every now and then. Let’s say there were songs that you started to get tired of… then I… then I tried to rate them bad so that they would not turn up all the time. [...] And songs that you really wanted would send [themselves] you tried to rate good as well.’

Yet another participant suggested that it was as if the Push!Music system sometimes ‘lives its own life’. Others referred to Push!Music as ‘magical’. Overall, people claimed that it was the autonomous sharing that made Push!Music special compared to other ways of sharing music, and even though they did not understand how it worked, they highly appreciated the results of it – that is, the spontaneously received and sent songs. They argued that Push!Music could be an exciting way to get inspiration to listen
to new music and break listening habits, and felt that the autonomously recommended songs were more unexpected than the ones they received from friends.

The implicit interaction with Push!Music implied that participants took a more passive role and let the system do the sharing for them. The motivations for doing this were several. One reason was that they were very curious to see what would happen when the songs autonomously shared themselves, and they therefore left their devices on although they did not listen to it. One participant explained:

‘...as you sit in school, you don’t have to listen to it but you can... I had mine on anyway just in case anyone would pass by... by coincidence... so that you have a large probability of a [music] transfer to happen. I had mine on every day, lying there, even if I didn’t listen to it.’

Another person said in a similar way: ‘...you put it [the mobile device] there and thought it could share music and then when you checked it you would have received something... or sent something.’ Several participants appreciated this way of sharing because it did not require any effort in terms of active decisions about what to share or listen to. Also, they simply ‘thought it was fun that it [music] turned up automatically.’

Importantly, the implicit interaction with Push!Music enabled a way of sharing with unknown users that the participants felt was more ‘balanced’. As mentioned previously, they were concerned about sending songs manually because it could be looked upon as intrusive, hinting also that they did not want to be hold accountable for sending a certain song. One participant expressed: ‘I don’t want any person to look me up because of that’, and worried that the manual sharing would lead to social interaction, which he did not want to engage in. Whereas the manual sharing could be seen as an explicit action on behalf of the user that brings with it such concerns, the autonomous sharing diminished the role of the sender and thereby also reduced some of responsibility of the sender.

The agency and autonomy of songs however revealed tensions regarding impression management. As any song could send itself – not just songs that give the ‘right’ impressions about a person – the autonomous sharing could potentially make it more difficult for the participants to manage their impressions. For example, one user manually sent a song to a friend and was quite taken aback when several other songs were triggered to autonomously send themselves to the same person – songs he did not even want to send. This incident generated lots of jokes in the group of friends about the sender’s taste in music. As a result, some participants tactically listened to and rated songs, in order to try to influence what songs would autonomously send themselves in the long run. One participant also suggested that he would have wanted to decide what songs should autonomously send themselves:
‘I would have liked a function: ok, I want to spread this song by Hello Saferide, so it’s labelled “please push this when I meet someone” instead of… ok, I can see Hans [another participant] but I don’t know who it is, [so] I can’t push to him, I don’t know that person, but if I tell it [the system] to push this [song] if it meets people, then it will spread it [the song] to people…’

This way, he would have been able to manage his impressions given to others, which he wanted to do, but still avoid any feeling of responsibility and accountability towards other Push!Music users.
Chapter 6

Discussion

The aim of this thesis has been to gain insights into how aspects of the physical and social context – in the form of sensor-based information – can be exploited in mobile media applications for playful use, through the design of prototypes and studies with users. As proposed, sensor-based information about the surroundings can be a rich resource in such applications, because it can make new dimensions and interaction possible. Based on the aim and what has been done previously in related fields of research, a design space was outlined that consisted of:

- mobile media on mobile phones;
- a wider definition of play that includes reflective, creative and exploratory activities in everyday life;
- aspects of the physical and social context that are possible to sense with sensors and which should be used to support people’s engagement rather than systems, and finally,
- agency and autonomy as a way to introduce unexpectedness.

This chapter will return to the aim of the thesis, and discuss the three interrelated research contributions: the two prototypes, the empirical results from the studies with users, and the collected design insights based on the designs and the studies.

Prototypes

The Context Camera and Push!Music embody two design concepts, based on different mobile media, of how aspects of the surrounding social and physical context can be used as a resource to allow new user experiences in mobile media applications for playful use.

The aspects of context that were used in the designs clearly widened the interaction with the two applications and brought with them new experiences, goals and practices. Dynamic environmental aspects of the surroundings became new parameters and made a new kind of photography possible, and the local social context of nearby connected users was exploited as a ‘filter’ for sharing music in combination with so-called media context that allowed autonomous recommendations of songs between these people.

Through the design and use of such sensor-based information, both prototypes were given a degree of autonomy and agency. Although the Context Camera does not strictly involve AI, the open and real-time use of
sensor-based information allowed the camera – through the visual graphics programme – to take a role in the picture taking. In Push!Music, songs could autonomously share themselves to other physically nearby users depending on similar listening history. The purpose of this was to introduce spontaneity and unexpectedness in the interaction, while still allowing the user to be the key actor, able to explicitly interact and influence what is happening. Both applications therefore allow a combination of explicit and implicit interaction, which had a positive effect on the overall user experience with regards to play and playfulness, as we will return to below.

The fact that these two systems each has been given an active role in picture taking and music sharing also distinguishes them from related systems such as the Hummingbird (Holmquist et al., 1999), tunA (Bassoli et al., 2006) and SoundPryer (Östergren and Juhlin, 2006). While the Hummingbird, tunA and SoundPryer ‘merely’ present the user with a social awareness of who is nearby; the current playlist of a nearby user; or the currently playing song of a car stereo in an encountering car; the Context Camera and Push!Music also influence the interaction and the outcome. That is, both the Context Camera and Push!Music autonomously influence and change the expected outcomes of the use – pictures and shared songs respectively – based on sensor-based information about the surroundings where a user happens to be.

The two prototypes differ from each other in a number of ways, such as the kind of mobile media and sensor data used along with degree of agency and autonomy, but there is another difference between them that is interesting to reflect on: Push!Music was designed to be a medium for social use, and the Context Camera was designed to be a creative tool for individual use. When it comes to Push!Music, users found it interesting and meaningful mostly when it was used in the proximity of other users. Using Push!Music as a way of sharing music to communicate and express for instance one’s taste or knowledge in music, some users felt that it was not a rich enough medium for them to express who they are to others, especially with people they have not met. With co-located friends, there was always the possibility to talk about shared songs, which several of them did and highly enjoyed, but with other unknown users it was more problematic. To these people, music sharing becomes meaningful only when they can communicate who they are through the sharing, and Push!Music currently lacks the support to do this in a, for them, fulfilling way. Finally, Push!Music was deliberately designed to be a technically straightforward system. An important insight was that it was not considered equally straightforward from a social perspective. Even though it was technically possible to send a song to anyone nearby, social rules and practices as well as existing social groups affected how people shared in a manual way.

When it comes to the Context Camera, a number of changes were made throughout the design process to increase the room for creativity, exploration, and personal expression. Many have tried to understand and describe what creativity is, and loosely it can be referred to as an ability to create ideas and concepts that are original, novel, and useful (Edmonds et al., 2005; Sternberg, 2005), although useful is not a necessary quality when
talking about creativity in art practices. With the early Context Camera prototype, users were concerned that it was too easy to take nice looking pictures, and that this resembled cheating (Ljungblad et al., 2004). As the early camera prototype allowed anyone to take nice looking pictures without effort, it diminished the users' feelings of being unique and ability to take original pictures. One participant explained that ‘all pictures turn out great now, regardless of who the photographer is’ and pointed out the importance of being unique as an artist. Therefore, the visual effects and mappings were made more complex and dynamic to increase the room for creativity and to require more effort to take pictures. In the final study, users seemed to agree that the camera gave them room to be creative, explore, and find their personal expression. However, as discussed next, it would have been interesting to study not only the individual experiences of Context Photography, but also what social practices would arise from sharing and collaboratively looking at context pictures. As the final Context Camera prototype runs on mobile phones with sharing possibilities, this would have required little effort from a technical perspective.

User Studies

The user studies have been invaluable in providing insights about the designs, the systems, and users' use, understandings and experiences of them. Several of the empirical findings and implications for design in this thesis are also useful to a broader research community beyond this thesis work. For example, the studies of Push!Music are relevant to the HCI and CSCW community because of their insights into mobile sharing practices between co-located people. One insight of value to researchers and designers of mobile social software, location-based systems and urban computing systems, is that sociability, rather than functionality, played a large part in the use of Push!Music. However, a related insight is that through the use of media agents, which allowed sharing without placing any responsibility on the user, people actually enjoyed sharing with unacquainted people in the vicinity and referred to it as an intriguing and fun activity.

As mentioned above, however, one could argue that it would have been interesting to study the social practices of Context Photography as well, and not just the individual use and experiences of it. After all, many reasons for taking pictures are highly social, such as showing pictures to others as a part of telling stories, sharing pictures to others as mementos, and as means to express oneself to others (e.g. Van House et al., 2005). How would context pictures fit into these practices? As there is no given rule for how one should interpret context images and their visual qualities, it would have been interesting to see how interpretation would potentially be something that had to be negotiated between the photographer and the viewers/recipient. There are also social perspectives of creativity such as social evaluation and social appreciation (Fisher et al., 2005), which would have been valuable to explore in relation to Context Photography. That is, context pictures possess a certain value to the individual photographer, but when shared with others, they would also be reflected upon and evaluated from the community’s
view on creativity and value, where they would potentially be valued differently.

Design Insights
As argued and shown in this thesis, different aspects of the physical and social context can thus be used to provide a rich resource in the design and use of mobile media applications for playful purposes. The section below, discussing the collected design insights, will bring up what has been particularly important with regards to encouraging playful use of mobile media.

Combining the Expected and Unexpected to Encourage Play
Both applications were given a degree of autonomy and agency through the design and use of sensor-based information about aspects of the surroundings. This implied that both the Context Camera and Push!Music could autonomously influence and change the outcome of use based on sensor data about a user’s surroundings. As a result, users were able to interact both explicitly and implicitly with the applications. This combination of explicit and implicit interaction with mobile media – essentially, the combination of the expected and unexpected – proved to be the most influential feature in the two designs.

On the one hand, users of the Context Camera and Push!Music had different but equally good reasons for wanting to interact explicitly and actively with the two systems. With the Context Camera, which encourages everyday playful creative use, people clearly wanted to be active in creating context pictures and be able to control the outcome, develop a skill at taking context pictures, and discover their own personal forms of expression. They searched for sources of movement and sound in the surroundings, or created input themselves or asked others to participate. One participant explained how ‘sometimes experiment[ed] with different movements and settings to get the effects you want’, which to him included an approach where ‘you move yourself or the camera more. Spin it etc. just to try to get a fun effect.’ Users switched between visual effects to explore them and find an expression that suited a particular picture. They further used the calibration function to consciously tone down or exaggerate the influence from a sensor to create the picture that they wanted, or simply turned one off in order to explore the other sensor.

In Push!Music, users enthusiastically took the opportunity via the system to explicitly send songs to friends for different reasons such as expressing their identity and strengthening the social cohesion in a group of friends. For example, they sent carefully chosen songs to friends to manage their impressions; they took the opportunity to send songs as gifts to other participants that they knew the recipient would appreciate; and they sent songs as pranks, in-jokes, and triggers for social interaction. Occasionally, they also explicitly sent songs to unacquainted users to trigger contact, disseminate favourite songs, and simply to explore Push!Music.
On the other hand, the majority of the Context Camera and Push!Music users took pleasure at the same time in not being able to control everything in use; that some things in the two systems in fact happened autonomously, spontaneously and unexpectedly depending on aspects of the physical and social context. In the Context Camera, the surrounding environment contributed to the images through the application in an unexpected way. Although users explicitly looked for a source such as a busy street to use in picture taking, they could not know for sure how the picture would turn out. A few people became frustrated when they could not entirely control the outcome and felt that a successful picture was as much a result of fluke – and the result of the camera as co-creator – as of skill. However, others gladly gave up some control and acknowledged that ‘you have to see it like depending on where you are, the picture turns out cool’ and that ‘much of the fun with context photography is that you feel you are not entirely in control over how the picture will turn out. The situation will determine this...’

In Push!Music, the media agents used accumulated media context to autonomously copy and send themselves between co-located users. Suddenly not only users but also songs themselves could decide what to share with other nearby users, which made people develop different strategies and practices to use and understand Push!Music. For example, they developed strategies to explore what affected the songs to share themselves; similar to how household members tried to understand both the Home Health Horoscope system (Gaver et al., 2007) and the Tableau Machine (Pousman et al., 2008). For example, one participant explained how he consciously tried to influence the media context through his listening and rating practices:

‘Well, I tried to rate tactically every now and then. Let’s say there were songs that you started to get tired of… then I... then I tried to rate them bad so that they would not turn up all the time. […] And songs that you really wanted would send [themselves] you tried to rate good as well.’

The autonomous sharing made users engage in an implicit interaction with Push!Music, which implied that they took a more passive role and let the system do the sharing for them. One reason was curiosity and wanting to see what unexpected things would happen autonomously without any explicit involvement. However, a more significant approach to using Push!Music was to rely on the system to share songs with other unknown users. As Push!Music could be seen as a ‘co-sender’, the role of the user as a sender was diminished, and this reduced users’ feelings of responsibility and accountability that several of them otherwise worried about. As Juhlin and Östergren (2006) have emphasised, it is challenging to design mobile face-to-face meeting support systems for public places since they involve a socially problematic practice of interacting face-to-face with unacquainted people. Importantly, in Push!Music, the media agents enabled a socially ‘acceptable’ and thereby also playful way for people to share with unknown users. This resembles how players enjoyed playing ShameStation (Kok et al., 2007), a game in which a player is controlling another person who is blindfolded, armed with a water pistol, and acting as a real-life avatar that
shoots on demand. Normally ‘shooting’ at people in real life with a water pistol is hindered by emotions like shame and guilt, but because of the game set-up in ShameStation, the question of who is to blame is triggered but provides no answer, which seems to avoid responsibility.

Taken together, the combination of explicit and implicit interaction encouraged users to be active and explore, while at the same time embracing and exploiting the inherently dynamic qualities of the surrounding environment. The fact that each of the two systems were given a key role in the interplay between users and mobile media – a role facilitated by sensor-based information, agency and autonomy – contributed to making the systems fun, exciting, magical, ‘live’, and real, according to the users. A key insight in this work is, therefore, that this combination of explicit and implicit interaction allows a bit of control, spontaneity and magic, which in turn seem to encourage play and playfulness.

The combination of control and non-control, the expected and unexpected, is also present and explored in game design, where one of the essential challenges is to find a good balance between them that allows for an intriguing and rewarding game. Basically, a game that is too easy is not stimulating, and neither is a game that is too difficult. People play games for a range of different reasons, such as overcoming a difficult challenge, seeking relief from everyday worries, and simply ‘for the joy of figuring it out’ (Lazzaro, 2004). Lazzaro reports that, for many, overcoming obstacles is the primary reason why they play games. In doing this, people play to test their skills, develop strategies, and feel accomplishment for succeeding or improving. Others play because they enjoy the excitement and curiosity of figuring something out, which initially revealed itself as ambiguous and mysterious. Further, many people play because of the social value of meeting people, sharing experiences, and competing against others. Regardless of reason, there is evidently a combination of the expected and the unexpected involved, as well as a tension between them, and hopefully also a balance, which altogether seem to invite and encourage playing games. A similar balance between the expected and unexpected has also been recognised as important in an attempt to define what is ‘fun’:

‘The issue that proved crucial to all our definitions of what really constitutes fun—and what fascinated everybody—was the borderline between unpredictability and security, between destiny and chance, and the relationship among risk, achievement, and penalty. Everyone agreed that fun that can be predicted totally is no fun. But then neither is fun that absolutely mystifies.’ (Davenport et al., 1998, p. 13)

Playing with Context

The combination of explicit and implicit interaction was enabled through the use of aspects of the physical and social context in the two designs – a use that differs from how similar information about the surroundings has been used previously in ubicomp and context-aware computing.
As seen in related work, sensor-based information about the surroundings can be used in context-aware systems to allow for pro-active support to users performing some task or action. This often means that systems are built to track, measure and model the environment as accurately as possible, and then react to changes in it to provide correct information or actions for the particular setting. Sensor-based information is then most often handled invisibly in the background and not made a resource for users directly. Different kinds of external factors can be used in the design of various leisure applications to take in aspects of the surrounding world. The Hummingbird (Holmquist et al., 1999), for instance, identified other nearby users and notified this to the user. tunA (Bassoli et al., 2006) identified other users in the proximity, and then let people tune in to listen to their playlists. The ‘seamful games’ (Barkhuus et al., 2005; Bell et al., 2006) have also investigated how information like wireless network coverage can be made visible to users so that they can exploit it as part of their game strategy.

This work on mobile media applications for playful use has involved an exploratory approach to how aspects of the physical and social context can be exploited in order to provide new opportunities for interaction, experiences, and practices. The purpose, here, of using sensor-based information about the surroundings has been to intrigue, make interesting, make spontaneous, encourage action and exploration, and make users aware of new perspectives, rather than providing relevant pro-active support depending on the situation. The use of sensor-based information has been explored in a number of ways, which together allowed the combination of the expected and unexpected:

First, it was left open to users to decide whether a sensor should be interacted with in an explicit or implicit way, or both. This was most noticeable in the design of the Context Camera, and the decision was fundamental to keeping it open for the two kinds of interaction, and to allow both the user and the camera, based on aspects of the surroundings, to influence pictures.

Second, by making the sensor-based information visible to users – in forms that were ambiguous as will be explained below, but yet possible to make sense of – it was brought to the foreground and could become a resource at hand for them to explore and play with. Making the information visible made it possible in the first place for users to become aware of it, and then act on it. In the Context Camera, this made users – rather than the system, as in context-aware computing – ‘aware’ of aspects of the surroundings, and it became a completely new experience to take pictures where one could also think of sound and movements. In Push!Music, it let users see who else is nearby, even users who are not visible in the physical world because of various kinds of obstacles. As Walther (2003) explains about play: ‘[n]ot only do we explore a world while playing. We are also driven by its potential meaning and the stories we can invent in that respect.’ Certain things from the real world were made visible, but without any explanation of what they mean, which leads us to the third strategy.
Third, it was left open for users to interpret what the sensor-based information and the result of using it in the interaction with mobile media could mean. This was in turn possible since we aimed at ambiguous representations of it. According to Gaver (2002), one of the important things to consider when designing for ‘homo ludens’, people as playful creatures, is to provide space for these people to interpret and appropriate the technologies in a way that makes sense to them:

‘[d]esigning for Homo Ludens means allowing room for people to appropriate technologies. Playing involves pursuing one’s inner narratives in safe situations, through perceptual projection or, ideally, action. If computational devices channel people’s activities and perceptions too closely, then people have to live out somebody else’s story, not their own’ (Gaver, 2002)

Finally, fourth, features were integrated so that users were given opportunities to control some of the actions and even override the use of the sensor-based information. In Context Photography, the aesthetic value appeared to be much more important overall than taking pictures that ‘represent a situation correctly’ as in many context-aware systems. Context pictures, too, are expected to be aesthetically pleasing and interesting. Therefore, a sensor calibration function was implemented so that users could actively decide for themselves how much they wanted sound and movement to influence the context pictures. This meant that they could even turn one or both sensors off, and change the influence to get another visual effect that better matched their taste or subjective view of a setting. In Push!Music, it was entirely optional to users to listen to received songs, even if the original idea had been to ‘push’ new songs for inspiration and almost make users listen to them. Received songs now ended up in a dedicated pool where the user then could decide what he or she wants to do with them.

To conclude, the insights from the use of aspects of the physical and social context have been valuable for the designs because they revealed four general perspectives on using sensor-based information:

- ‘open’ in terms of use and interpretation,
- visible to users,
- ambiguous in representation and meaning, and finally,
- possible to override or control at least to some degree.
Chapter 7

Conclusion

The aim of this thesis has been to gain new insights into how aspects of the surrounding physical and social context could be exploited in the design of mobile media applications for playful use. Two extensive case studies – Context Photography and Push!Music – have explored a design space of mobile media, play, and aspects of the physical and social context that are possible to sense with sensors, which support people’s engagement rather than systems, and with which the systems were given a degree of agency and autonomy. Context Photography used sensor-based information about the immediate physical environment to affect images in real time in a novel digital camera application for everyday playful creativity. Push!Music made it possible to share music both manually and autonomously between co-located people, using so-called media context.

The design insights gained from the designs, prototypes, and studies with users point at the value of combining explicit and implicit interaction – essentially, the expected and unexpected – to invite playful use. The combination of explicit and implicit interaction encouraged users to be active and explore, while at the same time embracing and exploiting the inherently dynamic qualities of the surrounding environment. This was enabled through the approach to sensor-based information about the physical and social context, which in this work has been open in terms of use and interpretation, mostly visible to users, ambiguous in representation and meaning, and finally, possible to override or control. The sensor-based information also gave the two systems a degree of agency and autonomy that allowed the systems to each take an active role in the interaction – which users thought contributed to making the systems fun, exciting, magical, ‘live’, and real. The combination of explicit and implicit interaction proved to allow a bit of control, spontaneity and magic, which in turn seem to encourage play and playfulness.

Play is an important part of life, and while new technologies offer vast opportunities to support it and make new ways of engaging in play possible, these technologies need to be designed in a way that embraces and encourages play and playfulness. This thesis has contributed with new insights into how this could be done in the domain of mobile media, through the use of aspects of the surrounding physical and social context. These design insights, together with the designs and empirical results, can hopefully both support and inspire researchers and practitioners in the design of future applications within the same domain and related areas.
Summary of Papers

Before the second part of the thesis, which contains the four research papers included in this work, this section provides a short summary of each paper as well as a note on my contribution.


This paper presents a summary of earlier design work in which we had started to explore Context Photography – a novel digital photography concept where sensors gather information about aspects of the surrounding environment that is used to visually affect photographs in real time as they are taken – and then implemented a Context Camera prototype. The main part of the paper reports on an exploratory user study with seven participants using Context Cameras for a six-week period in their everyday lives. The study provided insights into how such a camera is perceived and used, revealing the emergence of new goals, expectations, aesthetics and practice in taking pictures.

This work was highly collaborative throughout the project. Lalya Gaye, Sara Ljungblad and I equally shared all parts of the process: conceptual design, prototype application design, planning and conducting the study, analysing the material and writing the paper. During the prototype design process we also collaborated with Pontus Munck, who implemented an early concept prototype; Panajotis Mihalatos, who designed the graphical effects with our input as well as implemented an early version of the final prototype; and Mattias Rost, who optimised and implemented the final prototype to work on mobile phones.


Here we present a detailed account of the design process behind the concept of Context Photography and the Context Camera prototypes. In particular, we discuss our approach where sensor-based information is brought to the foreground to become a resource for interaction, available at hand and in real time to the users. Design criteria and rationale are brought up and discussed along with results from the exploratory user study in the paper above. This paper brings insight into implications of our approach to the design of sensor-based mobile applications for creative purposes.

All practical work behind this paper was done in collaboration with the colleagues mentioned above. However, here Lalya Gaye and I conducted a new analysis based on our gathered experiences of and reflections on working with the Context Camera. The new perspective of looking at
Context Photography as foregrounding sensor data as a resource, along with arguments, as well as writing the paper, were collaborative efforts.


This paper introduces the Push!Music prototype, which facilitates mobile music sharing between people who happen to be in the physical vicinity of each other. Push!Music allows both manual and autonomous sharing of music between users through ad hoc wireless networking, and provides a social awareness of other users nearby. It further reports on a two-week preliminary field study of Push!Music, where a group of five friends used the application in their everyday life. The study made it possible to start learning about the use of Push!Music within a group of friends. For example, we noted that the shared music in Push!Music became a start for social interaction within the group of friends and gave room for friendly pranks, and that received songs in general were highly appreciated and could be looked upon as ‘treats’. The users valued the autonomous recommendations of songs in particular.

This was collaborative work. Lars Erik Holmquist contributed with the idea of the media agents. Mattias Jacobsson developed the theory and underlying algorithms for the Push!Music system, with my input on design and user-centred issues. I also supervised Mattias Jacobsson during his Master thesis project, which was integrated with this work. Mattias Rost implemented the system to run on handheld computers, and he also conducted his Master project within the Push!Music project under my supervision. We planned, conducted and analysed the study together, although I had the main responsibility for those parts. I was also the main author of the paper with some input from the others.


After a brief presentation of the Push!Music prototype, this paper reports on a field study where 13 subjects used the system for three weeks. The main difference from the pilot study above was that we involved small groups of friends as well as participants who did not know any of the others, which opened for learning about the tensions that could arise when sharing music with friends and unacquainted people. In post-study group interviews, we continued to learn about Push!Music in use, for instance about the role of social awareness in the system, and how the participants shared music with friends versus with strangers, and what thoughts they had about the autonomous sharing. Based on the findings, we present implications for design that can be applied not only to mobile music sharing systems, but also to mobile media sharing in general.
Mattias Rost and I planned and designed the study together, and Mattias Rost had the overall practical responsibility during the study, which included solving technical problems, and handing out and collecting the devices from the participants. We conducted the three group interviews together, and my main contribution was later to do the analysis and write the paper. I was the main author of the paper with some input from the others.

Related Publications

The following publications are related to this work, but not included in the thesis per se.


References


