The Growth Plan: An approach for considering social implications in Ambient Intelligent system design

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Abstract. The technologies we use transform our behaviours and experiences. Particularly Ambient Intelligent (AmI) systems, envisioned to integrate extensively, will have a profound influence on our everyday lives. Design of these systems requires considering what kind of influence is desirable. This brings the ethical dimension of Ambient Intelligent system design to the fore. The design research approach presented in this paper is tailored to incorporate these ethical implications of Ambient Intelligent systems in the design process. The approach combines three central themes: advanced technologies, social implications and research-through-design methodology.

A three-phase development and evaluation plan, called the Growth plan, is proposed. The first phase, called Incubation, involves highly innovative and explorative concepts, created and tested in short iterative research-through-design cycles. *Experienciability* is key already in this first phase. In the second phase, the Nursery, AmI concepts are developed to a high level of detail and tested in a controlled lab environment. These experiments allow initial testing on how the AmI system transforms people's behaviours and experiences. The final phase is the Adoption, in which Ambient Intelligent systems are placed and evaluated in real life contexts. It generates knowledge related to the AmI system's actual influence on social life (in-situ ethical implications). The outcome of this approach is illustrated through the case study of the design an intelligent lamp. [1]

1 INTRODUCTION

The final decades of the twentieth century are marked by a rapid introduction and widespread adoption of digital technologies into everyday life. Mobile telephones, digital cameras, personal musical players, home automation devices, and many more, permeate the everyday one way or another.

The world of interactive technologies keeps developing, which paves the way for new kinds of technological presence in society. In the nineties of the last century, Marc Weiser at Xerox PARC formulated his vision of 'Ubiquitous Computing', in which computer technologies will 'weave themselves into the fabric of everyday life until they are indistinguishable from it' [1]. Computing power is no longer confined to specific devices like a desktop computer. Instead it is distributed in the entire environment and would support people's activities in such an integrated manner that the technology itself 'fades into the background'. While Ubiquitous Computing largely focuses on work environments, its European counterpart called Ambient Intelligence positions itself directly in the private life of people [2].

Ambient Intelligent products and systems have the following key characteristics [2]:

- Embedded: devices are networked and integrated into the environment.
- Context-aware: devices are able to recognise people and their situational context.
- Personalised: devices have the possibility to be tailored to personal needs.
- Adaptive: devices are able to adapt their behaviour in reaction to changes in a person's behaviour over time.
- Anticipatory: devices have the ability to anticipate a person's wishes.

The visions treated here are not purely theoretical exercises. They are a potent drive in current consumer electronics industry, and significant R&D budgets and government funding are allocated towards implementing these visions. The first products and systems inspired by the vision of Ambient Intelligence are currently entering the market [3].

The research approach described in this article views technology in general, and Ambient Intelligent technology in particular, as a *transformational agent*. This means that technology is considered to have the power to change the way people act in the world and experience the world [4]. Look for example at the way the adoption of the mobile phone made the way we manage our social relations more flexible [5].

Viewing AmI systems as transformative agent differs from current research directions in Ambient Intelligence research that are either purely technological [6], or that stress the experience side of these technologies [7], or that investigate the meaningful presence of these technologies [8]. Considering AmI systems as transformational agents brings an ethical dimension to the fore in their design process. Why and how would we want these systems to transform our behaviours and experiences?

The overarching aim of this research is to investigate how design research can help to foresee the ethical implications of the social transformations potentially brought about by AmI systems. In order to do that this research pairs three central themes: advanced technologies, social relevance and research-through-design methodology.

The current paper elaborates on the transformational role of AmI systems, which is our philosophical point of departure. The paper continues with treating the ethical dimension of AmI design. A design research approach is proposed next, called the Growth Plan, aimed at incorporating the transformational role of intelligent systems into the design process. This approach is illustrated with a case study from Industrial Design research.

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2 THE TRANSFORMATIONAL ROLE OF AMBIENT INTELLIGENT SYSTEMS

Philosopher of technology Peter-Paul Verbeek devised a framework that explains the transformational role of technology on human behaviour in more detail [9, 4]. His framework, called 'Technological Mediation', reveals the underlying structure of the influence products have on social life, and introduces useful concepts for the current research. A central idea in the theory of Technological Mediation is that technological devices co-shape people as actors in the world.

Through this 'mediation', transformations occur. Verbeek discerns two levels of transformation: The level of experience and the level of behaviour. When a person interacts with a product, this interaction influences the way he experiences his world and behaves in the world. Both these levels of transformation have specific structures.

Transformation of experience has a structure of amplification and reduction. This means that when a person interacts with a device, this interaction causes some aspects of reality to be amplified in the experience of the person interacting, while at the same time the experience of other aspects of reality are reduced. As an example, an mp3 player amplifies the experience of music. It feeds the audio signal directly into the ears, creating an immersive effect. At the same time, it reduces the experience of the sounds in the environment, since these sounds are blocked or overpowered by the mp3 player audio feed.

Transformation of behaviour has a structure of invitation and inhibition (Verbeek uses the phrase translation of behaviour. We use transformation of behaviour here to stay consistent with the terminology introduced earlier). Verbeek bases this part of his framework on the work of philosopher Bruno Latour who describes how 'scripts' for action are inscribed into devices. Compare the speed bump that holds the script 'slow down'. These scripts promote certain behaviours, and inhibit others. The mp3 player also provides an example for transformation of behaviour. It invites people using it to concentrate on their own work, for example by closing them off from other people's sounds in a busy train. At the same time, it inhibits social interaction with people in close proximity, resulting in less social interaction in public spaces. The mp3 player even influences behaviour of nearby people. They are less inclined to seek interaction with the listener as well, because he looks unapproachable.

The way the transformations of experience and behaviour actually occur is not exclusively determined by the properties of a device. This partly depends on the people engaged in interaction and the context of interaction. Just as products co-shape people, people also co-shape products. The telephone was originally intended as a hearing aid (Verbeek, 2006). Only since it is 'interpreted' as the communication device it is today, it transforms our actions and experiences the way it does now. So the transformations that occur in interaction with devices depend both on properties of the device, and the people interacting.

3 ETHICS OF AMBIENT INTELLIGENT SYSTEMS

As technology develops, new kinds of transformations of behaviours and experiences become possible. Ambient Intelligent systems are envisioned to be integrated into the environment, to a degree that surpasses most current systems like the example of mobile telephony mentioned before. They will mediate ever more of our behaviours and experiences and will thus transform our everyday lives profoundly. The way they will transform our lives is unknown, since these intelligent systems start portraying behaviour of their own.

If we agree that intelligent systems transform our behaviours and experiences, we need to take into account *how* we would like these systems to transform us [10, 4]. If transformation through technology inherently occurs, how can we give these transformations a desirable direction? The word 'desirable' brings the ethical dimension of intelligent systems design to the fore. What is a desirable transformation of behaviour and experience?

This ethical dimension does not exclusively refer to 'big' moral questions like those that play in cases of euthanasia or abortion. The transformation role of technologies we encounter in design mainly has an everyday character that is subtle, but nonetheless influential. It often remains implicit in the design process, but that does not mean the eventual effects on people do not exist. Anthony Dunne [11] sharply identifies and illustrates implicit values in design, and their effect on behaviour in interactive products: "[W]hile using electronic objects the use is constrained by the simple generalized model of a user these objects are designed around: The more time we spend using them the more time we spend as a caricature. We unwittingly adopt roles created by the Human Factors specialists of large corporations. For instance, camcorders have many built-in features that encourage generic usage; a warning light flashes whenever there is a risk of 'spoiling' a picture, as if to remind the user that they are about to become creative and should immediately return to the norm" [11].

As described earlier, an ever-greater part of life in society is mediated by technology, especially in case of Ambient Intelligent systems, resulting in an ever-diminishing *immediacy* in life. Trying to explicitly deal with the ethical dimension of mediation in design opens up new possibilities to contribute to people's quality of life, a phrase that often remains shallow and hollow. It is also a responsibility for designers of intelligent systems to consider possible influences these systems, which 'weave into the fabric of everyday life', have on everyday life.

4 DESIGNING FOR SOCIAL TRANSFORMATION: THE GROWTH PLAN

The design research approach described in the current paper aims to incorporate the ethical implications in the design process by using research-through-design methodology [12, 13]. In research-through-design, scientific knowledge is generated through cycles of creating and evaluating structurally varied, experiential and product relevant prototypes. This process is arranged by incorporating theoretical insights into the design variations, and empirically testing how the variations influenced the product experience. Research-through-design is essentially a holistic approach, which contrasts with purely analytic research. The holistic scope is needed to encompass the full complexity of Ambient Intelligent Systems and the influence on human experience and action. To investigate a systems influence on human behaviour, experiential prototypes need to be confronted with real people. Research-through-design has demonstrated its merits in the field of AmI related research [11, 14, 15, 16, 17].

Viewing AmI as transformational agent, poses additional demands on the research-through-design methodology. When it comes to evaluating the ethical implications of transformational systems, empirical studies in a controlled lab environment have limits [10]. Evaluation of technology that transforms everyday life is difficult in a controlled lab environment, simply because people do not live their everyday life there.

This article introduces a specific research approach directed at generating knowledge about the transformational aspects of AmI: the Growth Plan. This Growth Plan has three phases: Incubation, Nursery and Adoption. Each phase consists of a holistic design approach. Each consecutive phase involves increasingly detailed prototypes, (from sketch prototype to fully functional prototype) and becomes more realistic in terms of the evaluation context (from a lab context to a real-life environment).

The explanation of the phases is illustrated by a design research project from doctoral research into the transformational role of technology, conducted at Eindhoven University of Technology's Industrial Design department. The subject of this case study was to design an intelligent LED reading lamp that should influence people's behaviours in specific ways. These specific ways were defined using Schwartz's human value theory [18]. Human values are basic ethical concepts that guide selection and evaluation of behaviours. People differ in which values they find most important in their lives. Examples of human values are Creativity, Social Power or Helpfulness. The aim of this case study was to design lamps that invite behaviours that correspond to different values. For example, could the case study lamp invite people to behave more creatively or helpfully? This lamp could then help answer the question how people with different value systems evaluate the behaviours the lamp tried to elicit in terms of ethics.

The descriptions of the case study designs in this paper are intended as a concrete illustration of the Growth Plan phases and the nature of the resulting designs and tests. A detailed description of the case study is beyond the scope of this paper. See [10] for more information on the rationale behind the designs.

5 THE INCUBATOR PHASE

The Incubator is the early phase of development of AmI applications, with a strong emphasis on creativity, innovation and exploration. This phase involves quick iterations of prototypes and short research-through-design cycles (1 to 6 weeks). User needs, concerns and latent desires in relation to meaning and identity [19, 20] sociality and behaviour [21, 22] are coupled to creative design techniques [23, 24] to generate tentative and application specific design guidelines, and initial user and interaction models. The design result of this phase consists of early prototypes that can be evaluated through expert reviews. The most promising concepts continue to the Nursery phase.

In the case study, theory of human values [18] was selected as a framework to define desired directions for the transformation of behaviour. The main activity in this phase was to create concepts that had the potential to invite behaviours that correspond to values. This early concept development consisted of sketching (Figure 1), and developing early interactive prototypes using the plug-in sensor and actuator platform Phidgets [25], combined with Max/MSP programming [26]. See Figure 2. This first experiential prototype allowed for expert review on possible ethical implications of these designs, i.e., which behaviours they could elicit in terms of values.

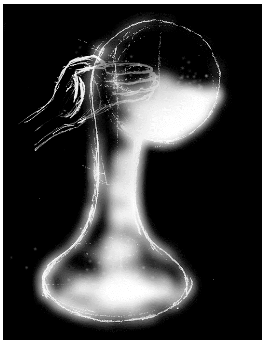

Figure 1. Intelligent lamp sketch. Light in this lamp is 'fluid' and can proactively follow an object, such as a book. It can also 'stick' to the hand, and that way be manually directed and distributed over the lamp. A design hypothesis was that the lamp invited Creativity related behaviours by offering an easy possibility to create lighting patterns on the lamp using the hand.

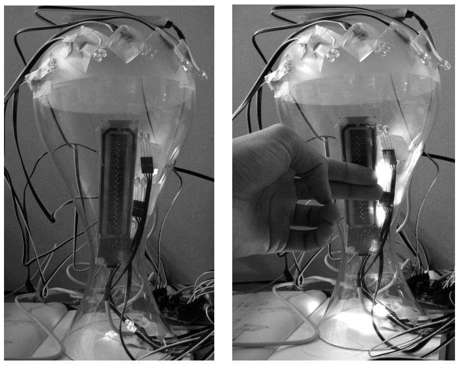

Figure 2. The first experiential, interactive prototype of the lamp. When the hand moves up, the light moves upwards along with it. The lamp uses two IR sensors to locate a nearby object and follows it with the horizontal top row of LEDs. Moving the hand across the surface creates a light trace.

6 THE NURSERY PHASE

The Nursery phase includes the first elaborate testing of AmI concepts. A 'Nursery' is an environment that allows controlled testing with participants, and is equipped with a range of measuring devices and facilities for empirical research. Such a space also allows fine-tuning of a system to the specifics of its context. An example of a Nursery space is the /d.search-labs context lab, which features spaces that resemble different quarters of a home [27]. The advantage of such contexts is that they enable controlled experiments. This control applies both to the way the system functions in its context, and to what kind of people participate in the experiments. The research-through-design cycles in this phase are typically longer than those in the Incubator phase (approx. 6 months to 1 year duration). The Nursery allows the three means of testing, that are considered complementary in literature:

- Physiological analysis [28, 29, 30]

- Psychological analysis [18, 31, 32, 33]
- Behavioural analysis [34, 35].

Additionally, the Nursery facilitates technical testing. It answers questions like if a concept is technically feasible or if it functions as intended.

The knowledge generated in the Nursery phase has the form of design principles for AmI, and models of how design parameters of AmI relate to human physiological, psychological and behavioural processes. From this knowledge one can extract tentative conclusions about 'real' ethical dimensions. The designs made in this phase are prototypes that are functional up to an experiential level: they seem like fully working prototypes.

The Nursery phase in the case study involved the development of the concept from the Incubation phase into a functional prototype (Figure 3), and testing it in a lab environment that resembled a living room context [27] (Figure 4). The lamp was able to portray three different behaviours in interaction, aiming to invite three different participant behaviours. For example, in one mode the lamp pro-actively followed the participants' reading material. In another mode, it allowed people to create lighting patterns on the lamp using their hands. The test involved a group of participants with specific, mutually different value priorities. For each of the three lamp modes, they were asked to explore the lamp's interaction possibilities and behaviours, and to create light for reading. Afterwards, they characterised the interactions using a set of value-related scales. The ratings were then compared with the kind of behaviours the lamp targeted with the three modes. Conducting the experiment indicated how different design aspects of the lamp design influenced the participant's behaviours and experiences. See [10] for more details.

Figure 3. Side view of the fully functional intelligent lamp. A Power LED array enables light beams in multiple directions. It uses a miniature camera for object tracking and has a touch sensitive top surface for manipulation of the light. The lamp is connected to a Powerbook G4 running Max/MSP, which controls its behaviour and does the image processing.

Figure 4. The functional intelligent lamp prototype was tested in a living room lab environment.

7 THE ADOPTION PHASE

The Adoption phase is directed at gaining knowledge about the influence AmI has as transformational agent on everyday life of people. As mentioned earlier, the true influence of a transformational agent can best be evaluated in-situ, in real life. The Adoption phase starts with customization of the systems for real-life, 'lived' contexts: An intelligent environment that works in a controlled lab environment does not necessarily work at the home of the Joneses, for example. Furthermore, the systems need to be rendered, which is not trivial for research prototypes. After installation in the targeted 'lived' context, the Adoption phase involves longitudinal testing in-situ, using methods such as contextual inquiry [37] and ethnography [38]. Knowledge gained from this adoption phase has the form of:

- User models that describe needs, values and behaviours in the real-life contexts.
- Models that describe long-term, co-shaping relations between AmI system properties on the one hand and behaviours and experiences of people in everyday life on the other hand.
- Robust design principles for AmI systems that integrate technology, models of in-situ behaviour and their social implications

Creating mobile, Adoption-ready systems and evaluating them in-situ is one of the biggest challenges in AmI research.

Currently, the case study is in preparation for the Adoption phase. The aim is to create a version suitable for use at home to enable long-term in situ testing.

8 CONCLUSION & DISCUSSION

This paper sketches a research-through-design approach directed at incorporating the social implications of AmI systems in the design process. Not all phases of the Growth Plan are tested yet through case studies. But the case study described in this paper points towards strengths of this approach and indicates weaknesses as well.

The main strength of the Growth Plan is that each phase ends with a prototype that allows experiential evaluation of the transformational workings. We argued earlier that the influence of AmI systems on behaviour could only be evaluated by having people experience interaction with such systems. In the Growth Plan, these evaluations already take place in the early phases of AmI development, and the lessons learned can be applied in the subsequent phases. This knowledge gained early on in the design process is not available in a process in which only one elaborate prototype is developed and tested. Another strength of the Growth Plan approach is that it stimulates testing in real life. This is something that is often not pursued due to its complexity.

Weaknesses of the Growth plan are the time and resources it may take. Building a Nursery context that allows testing in a controlled lab environment is not trivial. It also takes extra time to create and evaluate prototypes in multiple cycles. Then again, the responsibility and opportunity of system designers to consider ethics when bringing new AmI systems to everyday life deserves full attention.

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