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Embodied Interaction or Context-Aware Computing?: An integrated approach to Design

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Abstract. This paper revisits the notion of context from an interaction design perspective. Since the emergence of the research fields of Computer supported cooperative work and Ubiquitous computing, the notion of context has been discussed from different theoretical approaches and in different research traditions. One of these approaches is Embodied Interaction. This theoretical approach has in particular contributed to (i) challenge the view that user context can be meaningfully represented by a computer system, (ii) discuss the notion of context as interaction through the idea that users are always embodied in their interaction with computer systems. We believe that the particular view on users context that the approach of Embodied Interaction suggests needs to be further elaborated in terms of design. As a contribution we suggest an integrated approach where the interactional view of Embodied Interaction is interrelated with the representational view of Context-aware computing.

Keywords: Embodied Interaction, Context-aware computing, Design, Representation, Context

1 Introduction

In his book *"Where the Action Is: The Foundations of Embodied Interaction"* [1], P. Dourish introduces the idea that tangible and social computing have a common denominator. They both exploit the idea of people's familiarity and facility with the everyday world, be it a world of physical artifacts or of social interaction. "This role of the everyday world here is more than simply the metaphorical approach used in traditional graphical interface design. […] Instead of drawing on artifacts in the everyday world, it draws on *the way the everyday world works* or, perhaps more accurately, *the ways we experience the everyday world*." (p. 17, orig. italics). Dourish explains that both tangible and social interactions "draw on the fact that the ways in which we experience the world are through directly interacting with it, and that we act in the world by exploring the opportunities for action that it provides to us – whether through its physical configuration, or through socially constructed meanings" (pp. 17).

The Embodied Interaction approach [1] can be regarded as a picture of a user actively engaged in human computer interaction. The focus lies on how interaction is played out when the activity develops smoothly and problem-free; when our daily interaction is handled effortlessly, without reflection. The Embodied Interaction approach thereby portrays human agents as engaged in an interaction characterized by skilled and continuous coping. It thus describes an understanding of human computer interaction that can be exemplified with a user finding herself in a situation of being able to handle all difficulties and not losing focus in her activity even once. How she gets there and how she manages to remain in this focused activity, is out of the scope. But how well does this picture of skilled and engaged human computer interaction guide design? And more specifically; How well does it guide design of context-aware systems?

To understand these questions better we need to return to one of the targeted problems of Embodied Interaction. Namely the gap between the social conception of context and the technical one [2, 3]. Embodied Interaction is but the latest contribution to improving the understanding of this gap. It uses the philosophical tradition of phenomenology as a theoretical departure point for understanding interaction. This tradition has previously been presented in the HCI research community, since it seems to offer a way to take both social and technical views into account. Based on the "present-at-hand" mode of use, Winograd and Flores [4] discuss user activity in terms of "breakdown". Weiser [5] introduces the concept of transparency, in calm computing and ubiquitous computing research, based on the "ready-to-hand" mode of use.

The approach of Embodied Interaction relies much on the idea of a well practiced and smooth interaction, with and through computers, and it deemphasizes the developmental aspects of the user activity. Without addressing these developmental aspects, it is difficult for designers to operationalize the approach of Embodied Interaction in their work. Without looking at how you become a skilled user in the interaction with a system, one opportunity for design is passed over.

Advocating history of use, Chalmers [6] have argued that the ideal of transparency, which can be also found in Embodied Interaction, is an unachievable goal. Räsänen and Nyce [7] have pointed out that the approach of Embodied Interaction is reductionist in that it does not go beyond interaction, and focus the here and now too much. We will go one step further to claim that Embodied Interaction does not take all modes of interaction present in the activity into account, and thereby misses out on how skill is acquired. In this respect we will claim that the Embodied Interaction approach overlooks the interplay between learning and practice, between reflection and action that characterizes any kind of human computer interaction. This observation is particularly interesting for design of context-aware computing systems because this field has strong connection to Embodied Interaction.

This paper revisits the notion of context in the field of context-aware computing from an integrated design perspective on Embodied Interaction. We believe that the rich conceptualization of Embodied Interaction deserves to be further developed in terms of design of context-aware computing systems. This leads to the following question: How do we design for context-aware computing systems in the light of Embodied Interaction?

In this paper we will not try to answer questions about proactivity in context-aware computing. Instead we follow Rogers [8] in that what we aim for is not proactive computing but proactive people.

2 The notion of Context from an Embodied Interaction perspective

Grounded in Merleau-Ponty's Phenomenology of perception [9], Schutz's Social phenomenology [10] and Heidegger's Hermeneutic phenomenology [11], Dourish [1] suggests a theoretical approach to human computer interaction which he coins Embodied Interaction. The Embodied Interaction approach views context not as information but as a relation and, as human actors participate in the world, action does not occur in a particular context but context is rather created and recreated in concert with interaction [12]. Because of this, context is not stable but instead a dynamic feature; constantly changing. What is to be regarded as context is thereby determined by the setting, actors and interaction.

According to the Embodied Interaction perspective context is not some delineable aspect of a setting that can be encoded and represented [12]. Rather context is something people do. In this way the context model in Embodied Interaction is an interactional model and not a representational model [12]. The view that context is what people do, comes from the primacy of action in Embodied Interaction. An emphasis on action is shared with Situated Action [13], which is also one departure point for Embodied Interaction. Both approaches regard *context* and *meaning* as continually changing and only possible to recognize in how interaction unfolds. According to Embodied Interaction, the way we interact with a computer system is a sign of how we relate to the system. Meaning is also embodied, both in a physical and a wider sense. In this way our interaction is dependent on our physical, social and cultural body.

The theoretical approach of Embodied Interaction argues against disembodied, objective and reflective use. What Embodied Interaction instead focuses on, inherited from embodiment [9] and being-in-the-world [11], is a moment of mindless interaction, a moment of skilled coping.

3.1 Challenges for context design from an Embodied Interaction perspective

Dourish [1] suggests the following six principles as a backdrop for design (pp. 162):

1. Computation is a medium
2. Meaning arises on multiple levels
3. Users, not designers, create and communicate meaning
4. Users, not designers, manage coupling
5. Embodied technologies participate in the world they represent
6. Embodied interaction turns action into meaning

When trying to design for context from the Embodied Interaction perspective, we are left with these broad design principles. That the principles are broad make them difficult to operationalize. This while the alternative of designing for context, using objective representations, is merely seen as positivist thinking, incompatible with the philosophy put forward by Embodied Interaction [12]. Take for instance the third and fourth design principle above, they directly address the role of designers although they do so in a rather negative, excluding sense. Principle number three and four state what designers of these systems should not do. Thereby the role of the interaction designer seems to be marginalized, to an enabling one. It is probably not meant that the ideal we should strive for is the ultimate and final system, allowing for every kind of appropriation and every kind of interaction. Dourish [12] notes that one and the same system should support evolution: "[...] our concern is not simply to support particular forms of practice, but to support the evolution of practice—the 'conversation with materials' [Dourish quoting Schön [14]] out of which emerges new forms of action and meaning." (p. 25). This seems like a contradictory claim as the evolution of practice is only known in retrospect and in analysis. So how can this be used for claims about design?

In a passage about Place and Space, Dourish [1] writes: "…place can't be *designed*, only designed *for*." (p. 91). If Embodied Interaction is about meta-design, then what are the remaining implications for design, and especially design for context? Our interpretation of Embodied Interaction is that interaction designers should leave context and meaning as open to appropriation as possible. What designers ideally should strive for, then, is completely open systems. In these computer systems each user can interact with the most suitable content and structure. The computer system has, from this particular understanding of interacting with computers, to be able to show every possible structure and the current state and configuration of the system [12].

From an Embodied Interaction perspective on human computer interaction, we can design user interfaces, but not how they should work, as creation of meaning should be left to users in their appropriation of the interfaces. Because we are not allowed to design how an interface should work we also cannot explicitly support skill acquisition. In Embodied Interaction skill acquisition is not an issue because it is does not belong in the picture of skilled and engaged coping, and thereby it falls outside the scope of Embodied Interaction. As a result, acquiring skill becomes something magical, something designers will not need to attend to.

The Embodied Interaction approach has an interactional model of context. But if the notion of representation is absent in the description of interaction with a systems how can designers design for this interaction? The concept of representations is key for the design of computer systems and especially context-aware computing.

3 The notion of Context in the field of Context-Aware Computing

In context-aware computing the notion of representations of context is seen as a prerequisite for designing context-aware systems. The assumption is that it is possible to divide the context of a device (or a user) into smaller parts and that some of them are more or less objective and stable. Thereby it is possible to meaningfully represent them in a computer system hosting the device.

For example Dey et. al. [15] reasons in terms of identifying and analyzing the constituent elements of context. In identifying and analyzing the constituent elements of context, ubiquitous computing research is bottom-up, starting with sensor data representing aspects of the physical environment [15]. One example is when sensor values as GPS coordinates are used in navigational applications. Starting from sensor values then context and meaning is inferred up to the level of human interaction with the device.

As described in Dey et. al. [15]: “One hypothesis that a number of ubiquitous computing researchers share is that enabling devices and applications to automatically adapt to changes in their surrounding physical and electronic environments will lead to an enhancement of the user experience.” (p. 100). One last step then is to use the model not only to adapt, but also to try to foresee what is going to take place next and let the application act proactively, guessing what users soon might need to have at hand. In this case questions for system designers are how to adapt to context and how to act proactively in context. Obviously, it is a very hard problem to get all these abstractions, models and inferences right. It can certainly be questioned whether these systems will ever succeed outside very specific domains with very limited scope [8, 16].

3.2 Challenges for design of Context-Aware Computing systems

Context-aware computing has been blamed for making only small advances and relying too much on systems engineering to solve problems origination in human interaction [3, 17]. It is also questionable whether we will see a major breakthrough in context-aware computing any time soon as the problems of strong AI and proactive computing are still far from solved [8]. The problem for context-aware computing lies in the representational models that are built in context-aware computing. In a representational model there are inherent questions about what is represented and how it is represented. The next question is how different representations are related. Computational representations use specific values, structures and interrelations. There is no vagueness involved, but every possible value, structure and interrelation have to be decided in advance by the designer. The effect of these decisions is that the behavior of each model of context is also at a basic level determined in advance. Because of this the user model and the system model will diverge as soon as the context-aware system is put in use. The context-aware computing solution to this divergence is either to add an exception to the model every time it diverges or to trust in future AI advancements to solve all discrepancies.

In the field of context-aware computing physical and digital representations of context are building blocks of design. As opposed to human and social representations, designed representations are bounded in terms of structure and contents. In computer science, representations are the internal software components that together make up a computer program. These digital software components rely on physical hardware components, which in turn bound the representational power. A computer system is then itself built on representations and therefore cannot be non-representational. But this still allows for non-representational use, with embodied physical or digital representations. This duality between non-representational use and designed and bounded representation is present in every interaction with something that is designed.

The representations of context in context-aware computing are seen as objective because of their origin in sensor values. But this concept of objective context should not be interpreted as absolute. Even for instance, GPS coordinates are only valid within their social frame, which in this case is a very wide frame. Chalmers [18], in accordance with Ricoeur and Gadamer, writes: "'Objectivity' comes from distanciation: representation is fixed, dissociated from intention and only displays universally shared references. […] objectivity is not absolute. Instead, we see degrees and forms of distanciation." (p. 213).

Also on objectivity, Dourish [12] writes: "In contrast to the objective and quantitative nature of positivist theories, phenomenological theories are subjective and qualitative in orientation. By 'subjective' I mean that they regard social facts as having no objective reality beyond the ability of individuals and groups […]" (p. 21). The interpretation of this is not that everything is subjective in the sense that everyone has their own interpretation, different from everyone else's. If this were the case, we would not be able to relate to what others do, we would simply not be able to engage in any interaction without questioning every step of it. Instead we socially create meaning, which we use in interaction. That is: 'objective' and 'subjective' may not be so far apart.

As the extreme of objective representations is never the case and as it is impossible to design for the completely subjective, we need to find a point where we can agree. If "groups" in the previous quote is taken to be the people we design for, then we are essentially agreed, and can meet half way between objective and subjective.

4 Towards an integrated approach: Reintroducing the concept of representations to Embodied Interaction

At some level computer technology is always designed. In fact we both design human computer interaction and we design *for* human computer interaction. One extreme is the socio-cultural approach. Relying on ethnographical methods, we start out by describing specific users as a basis for design and then design *for* context. In this view human action is in focus. Action is performed within context at the same time as context is interpreted and recreated. With this focus context is never stable and therefore cannot be deliberately designed. The remaining option for a designer is to support user context formation by relying solely on user appropriation. Human action is subjective and situated, rendering each interaction different from the previous one. In Table 1 this corresponds to "action" as mode of use and because of the subjective nature system designers can only support interaction and design representations *for* context determined by users. The other extreme is the technology perspective, where we design representations of context and let uses adapt to these representations. Context is modeled using objective and stable representations of sensor values. Users can then interact with this computer model where use is objectifying and reflective. The mode of use as seen in Table 1 is characterized by reflection on representations *of* context.

Table 1. Mode of use related to artefacts of design

Mode of use	Design artefacts
Action	Representations *for* context
Reflection	Representations *of* context

To combine results stemming from these two approaches is challenging, e.g. [12]: “Translating ideas between different intellectual domains can be both exceptionally valuable and unexpectedly difficult. One reason is that the ideas need to be understood within the intellectual frames that give them meaning, and we need to be sensitive to the problems of translation between these frames.” (p. 20) . On fundamental ontological disagreements it is questionable whether it can be done at all. On context in computer supported cooperative work and ubiquitous computing, despite the seemingly contradictory approaches, there have been many attempts to bridge or at least narrow the gap between these two intellectual frames [3, 19]. An alternative to bridging the gap would be to acknowledge that the both sides, computer representations stemming from sensor data and analytical representations of context are necessary. Instead of searching for one common ground for these views of context we note that they are two sides of the same coin.

When learning a new system much time and effort goes into figuring out how the system works instead of engaging in the activity itself. At first when the system has been learnt it can be handled without reflection, with skilled and embodied interaction. But still there are instants when “an event ‘leaps to the eye’ because it is expected or is a deviation from that which one would expect” [20] (p. 294). Also Heidegger also noted this (here in the words of Dreyfus [21]): “…mental content arises whenever the situation requires deliberate attention.” (p. 70). These points show us towards an answer in revisiting Heidegger’s original view of hermeneutic phenomenology. His famous example with the hammer does not only serve to show how the hammer is transparent in ready-to-hand use, but also how “breakdown” (when the head falls off and the hammer becomes present-at-hand) leads to acquiring skill (in avoiding this malfunction in the future). As Dreyfus [21] says when clarifying Heidegger “…the occurent is necessary for explaining the functioning of the available…” (p. 121). Here Dreyfus uses the terminology “occurent” instead of present-at-hand and “available” instead of ready-to-hand. Figure 1 shows how ready-to-hand action and present-to-hand reflection are interrelated. With this integrated view there is no necessity to choose between action and reflection, no necessity to choose between designing representations *for* context and designing representations *of* context. Instead the mode of use repeatedly shifts between action and reflection.[1]

Take GPS positioning for example. Most of the time the coordinates are correct and a user can interact with the navigational program without paying too much attention. The mode of use is here seen as “action”. But there are certainly occasions when the mode of use shifts to reflection; for example when a breakdown in interpretation occurs because of a mismatch between the map position and the

[1] Since both modes of use can be found in the Hermeneutic phenomenology of Heidegger there might be no ontological disagreements in the end.

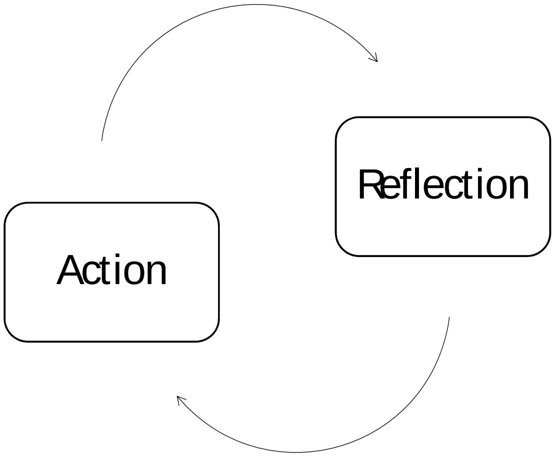

Fig. 1. The two modes of use as interrelated

position in the real world. Another breakdown could occur when a user moves indoors and gets a message about lack of coverage. In both these examples, interaction is interrupted and the user may need to reflect upon what the problem is, to be able to find a solution (e.g. update GPS-data or move outdoors) before interaction can be reengaged.

Objective representations for context are not only to be seen as harmful, constraining user context, but they also form a structure to relate to in a hermeneutic interpretation. Instead of trying to give guidelines for how to design one ultimate design, we need to acknowledge that a design and thereby also the designer is part of this hermeneutic development and that continuous redesigns, done by both designer and user, are necessary for the system to stay relevant to a user.

5 Discussion

The Embodied Interaction perspective has both turned away from, and argued against objective representations for context. Although the Embodied Interaction view of context contributes to a better understanding of human interaction with and through computers, at the same time it marginalizes objective representations for context without offering an alternative basis for design. Maybe it even marginalizes design as a whole. It is time to turn the perspective back again to enable both design *of* context and design *for* context.

The alternative to design systems completely open to appropriation is to use current descriptions of context as a basis for design. If we cannot use current descriptions, but instead need to leave more open for appropriation, then the role of the designer is marginalized accordingly.

Computer systems always have room for interpretation and appropriation, but through careful design appropriation and skill acquisition can be guided. Leaving more open to appropriation means constraining the choices that the designer has. A similar trend in design was when the concept of affordance became the one guideline overshadowing all others in HCI.

Given the Hermeneutic phenomenology perspective, it poses no problem to reintroduce objective representations of context in the philosophy put forward by the Embodied Interaction approach. Action and reflection are just different modes of use where present-at-hand reflection is an important complement besides embodied ready-to-hand action, and it is not one or the other. Users act in context by (hermeneutically) going back and forth from ready-to-hand embodied interaction to present-at-hand reflection and back again.

Our integrated approach undoubtedly have much in common with Winograd and Flores [4], focusing "breakdown" as important, but there are differences. They came to the conclusion of modeling computer use through utilizing a state machine representation of speech act theory, with labeled states and directed arcs. Our approach is to use present-at-hand categories, but not to build a general model that enforces some elaborate structure. Instead we only point to the interrelation between present-at-hand and ready-to-hand. This approach can be used either to build general systems with small descriptive powers or specific systems with large descriptive power. But our main contribution is that the present-at-hand categories give us a way of talking about design, while still relating to ready-to-hand Embodied Interaction.

It is interesting to note what Dourish [1] write about the states of ready-to-hand and present-at-hand. Dourish explicitly refers to these "states" when discussing coupling using a computer system as example: "If there were simply these two states […] However the truth is more complex. As we have seen, the tools through which we operate when interacting with a computer system are not simply physical objects, but software abstractions, too. There are very many of these abstract entities in operation at any given moment, and programs link them together in a variety of ways." (p. 139). This surely gives the impression of great complexity. Dourish ends this passage in the following: "The consequence, then, is that there are very many different levels of description that could be used to describe my activity at any given moment. Some, perhaps, are ready-to-hand and some present-at-hand at the same time […]" (p. 140).

But that some entities are ready-to-hand while others are present-at-hand is nothing new. On a conceptual level even when Heideggers' hammer was ready-to-hand some other part of the activity was present-at-hand. Computer systems does not change this. If we design these systems with using present-at-hand categories deliberately, we might even bring Embodied Interaction one step forward.

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