



Figure 1: Does playing with our kids while wearing Google Glass turn this activity into a series of photo opportunities?

Co-Embodied Technology: A Design Space for Human Being

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Abstract

We sketch out an alternative design space between traditional 'digital technologies' and 'physical product design'. We call this design space *Co-Embodied Technology* (CET) and position it against more representational approaches. Using *skill, scaffolding, traces and social coordination*, we discuss two TEI design examples we find promising for developing CET.

Author Keywords

Embodied, Situated, Co-Embodied Technology

ACM Classification Keywords

H.5.2. User Interfaces: Theory and methods.

Introduction

Computers are increasingly becoming part of the activities that give meaning to our lives. Thus, the computer is starting to form an inherent part of our 'human being' as we live it on a day-to-day basis. Many approaches, such as tangible interaction, augmented, wearable and ubiquitous computing and whole-body interaction have arisen that offer support to connecting computers to this everyday life.

We are quite sympathetic to the goal of putting digital processes into our embodied, or 'lived' world. Yet we also issue a warning. Technologies that too simply connect digital information to the physical world might actually miss the point, and result in achieving the reverse effect. That is, instead of a desirable situation, in which digital processes are meaningfully taken up embodied human practices, we might end up with a situation in which the world we live in becomes subsumed under the digital process in question. Take, for example, the recently presented Google Glass. Does wearing Google Glass enhance integration of digital processes with our physical and social environment? Or does wearing Google Glass mean we will perceive our environment as first and foremost a 'resource', something we 'use' as input or output for the App that is running in the corner of our eye? What if, through wearing Google Glass, we perceive playing with our kids only as a series of 'photo opportunities' (Figure 1)?

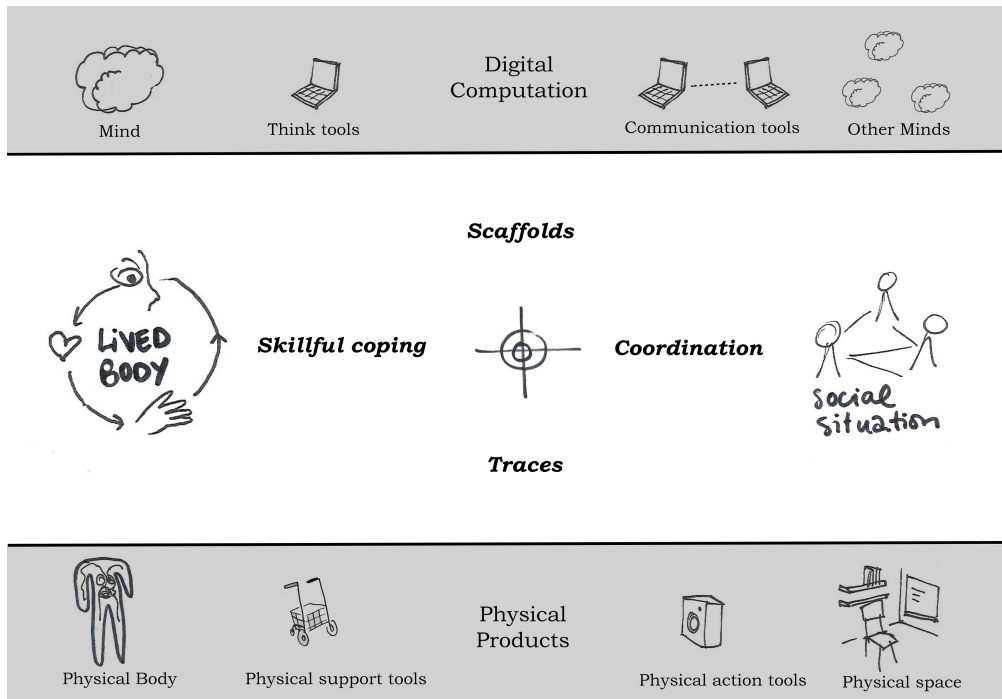


Figure 2. A design space we call Co-Embodied Technology (CET), where sensorimotor coupling by the lived body meets situated practices in the social situation. Here is a space for design that combines digital technology and physical product design in new ways. Instead of explicitly mapping digital computing to physical form through representation, CET connects to our skills, scaffolding, traces, and social coordination (terms explained in text).

What computers still can't cope with

Computers cannot deal with the physical and social world in the way we live it directly, but must do so through digital representations of it, that is, by processing 'data'.

What happens when computers become part of our everyday lives, which are not necessarily governed by 'data processing' activities? The philosopher Dreyfus has insisted that we should be pessimistic on the prospect [3]. Everyday human affairs fundamentally involve skillful, embodied ways of dealing with the world in action, what Merleau-Ponty calls the process of

'achieving grip' [7]. According to Dreyfus, this is something that computers cannot deal with, by their very nature. Furthermore, Agre [1] explains how computer engineers tend to see all human practices as instances of information processing, ignoring everything that doesn't fit that picture. He underscores that computing is itself a human practice, just like any other human practice, albeit one that tends to hi-jack and then transform all other human practices 'in its own image'.

However, we are not as pessimistic as Dreyfus and Agre. Within the fields of tangible, augmented and wearable interaction we see a promising merger of Human Computer Interaction with Industrial Design [E.g. 6]. Here again we see the intuitive desire to put digital processing 'back into the real world'. This can be deepened by grounding it in a fundamental critique of the traditional, Cartesian conception of the human mind and behavior. The critique argues against seeing human thought as detached from the actual world in which the body is situated. Drawing upon theories of Embodied Cognition and related philosophies, it posits that human being is always concretely situated as an ongoing sensorimotor interactions of a 'lived body' in its physical- and social environment, and that this is what brings forth a meaningful world [4]. In these 'embodied and situated practices' of our everyday life, dedicated instances of rational problem solving are rare, if not completely absent. This conceptual backdrop might help to fuse design with Dreyfus's 'embodied coping'.

The challenge

Given the current omnipresence of digital computing in our lives, we see an urgency to develop a vision on Co-Embodied Technology. In our vision, CET is not a

Figure 3. Mapping TEI projects (TEI '11, '12, '13) to the CET design space. One sees that most existing projects are positioned in the top half of the diagram, as they implement a representational mapping between physical and digital, with focus on the digital function. These are tangible objects used as means to access to digital information. In the center, however, a small number of projects more strongly relate to what we see as CET, connecting to sensorimotor coupling and social interaction. Two of these we discuss in the text.



straightforward mixing of physical and digital: it involves careful design, tailored to the specific contexts of every project. It means developing technologies that truly do justice to the embodiment of human being. Designs are needed which constructively build on, augment and develop people's embodied forms of sensemaking, not in the restricted functional applications of factory or office, but with regard to human being in the broadest sense of the word. This alters both overall design goals, and the relations between digital and physical as we show below

We believe that technologies that help people to reconnect body and mind by enabling them to skillfully and emphatically live their lives in a meaningful way should be part of human-centered design. If, on the other hand, we fail to understand the deep implications

of notions of embodiment and situatedness, we run the risk of creating, despite good intentions, a hybrid interactive environment, where digital and physical forms may be mixed extensively, but which would in fact take us even further away from our embodied being than ever before. And if this scenario was realized, escape might prove impossible, precisely because of technology having become so pervasive!

Our vision of Co-Embodied Technology

Our vision for Co-Embodied Technology is sketched in figure 2. At the top we see the classic interpretation of mind as dealing with abstractions (ideas, rules, methods, procedures and the like), potentially in communication with other minds. Both individual thinking as well as communication with others can be supported using appropriate digital information processing technologies. This is the classical view of the computer as a tool for thinking. At the very bottom we see an equally traditional interpretation of product design as supporting the physical body in manipulating objects and processes in the physical environment.

In between we reveal a new design space that holds aspects of both physical- as well as digital process. However, the combination of physical and digital is not one of purely 'stitching' the two together (as would be the case in designing digital controls for a fridge). Nor do we propose to connect digital to physical by means of a representational mapping, in which the physical form would *stand in for* (represent) the digital process (as is the case in many tangible interaction designs).

Instead, in the center of our diagram we discover on the left the *lived* body that is continuously in interaction with the environment through sensorimotor coupling

processes that enact a world of meaning. This lived body is not the physical body at the surgeon's table, nor is it the floating Cartesian mind: it is a lived body in the phenomenological sense [7].

In the world that the lived body enacts we recognize the 'situated practice' [8]. The idea of situated practice emphasizes both the active, achieved nature of the world as something we bring forth, rather than discover and analyse, as well as the fact that our world is always a social world, in which people coordinate each other's behavior in ongoing social interaction.

The process through which a person becomes meaningfully situated in a practice can be, and most often is, mediated by handling artifacts. So the question we put to designers and engineers, from this perspective, is what these artifacts should be like in order to support that process of 'enactment'. That is: Right at the heart of this diagram, where the sensorimotor coupling of the lived body meets the context of a socially situated practice, is where we see opportunity to design Co-Embodied Technologies.

Our vision differs from the 'standard' approach to tangible interaction which focuses mostly on the representation of information. Instead, following [6] we appreciate embodied skills as the basis for design:

"We are interested in actions rather than representation of information: Actions that allow humans to build skills; in keeping with the use context and the non-computer artefacts in it." [6]

Our vision can be seen as a follow-up on the proposal of Dourish's Embodied Interaction [4]. However,

Embodied Interaction seems to lack a coherent view on how the 'physical' relates to the 'social'. Dourish has explicitly attempted to call attention to both the 'physical-embodied' and 'social' aspect of human conduct, but he describes them as two separate design fields, and proposes technological artifacts that support either the one or the other separately. Dourish presents tangible media projects as implementing sensorimotor coupling and natural affordance, while these examples are actually rather representational in nature. In separate chapters he describes social collaborative tools that in turn have little to say about the body and its capacity for creating sensorimotor couplings as skillful coping (presenting quite conventional GUI interfaces for CSCW purposes, for instance). CET, instead aims to show how physical objects are always already social objects, and how social interaction is always determined by the physical space in which it takes place. Based on CET we may start to develop interactive technologies that accommodate integrating the 'social' and the 'physical'.

Changing the design question

CET is concerned with the general question of how to add meaning to people's lives. This is different from projects that are part of an organizational or commercial goal, aiming to optimize certain tasks or behaviors. Instead, we target questions concerned with how to help people:

- acquire & refine skills that are self-rewarding?
- perceive the world with more refinement?
- gain more autonomy over their lives?
- be more empathic in relations with others?
- be creative in everyday routines?

- focus on what is most important to them?

Changing the focus of interaction design

In CET the focus is no longer on mapping the physical to the digital through representation. Instead we see possibilities to support a person's enactment of a socially situated world. This can be done by combining the following aspects:

Traces: As a result of people's actions, traces are left in the environment that can later be used by people to make sense of the situation. Interactive technology may enable new kinds of traces.

Social Coordination: People coordinate social action 'in situ'. Interactive technology could mediate such face-to-face social coordination in new ways.

Skillful tool-use: Interactive artifacts can become an extension of the body for developing and exercising our skillful way of dealing with the world.

Scaffolding: Technology can help people to create physical-cultural artifacts that support making sense of what what one is doing, right in the act of doing itself.

Examples

We analysed design proposals from recent TEI conferences (TEI11, TEI12 and TEI13). We asked ourselves which of the available design proposals offered potential for adding to the development of CET. As can be seen in figure 3, most projects contained a representational interpretation, where physical form is used to access digital information.

We discovered several projects close to our idea of CET. These draw on aspects of skills, scaffolding, traces,

social coordination, or a combination. In this short paper we have space to discuss two of these examples.

Bowl Splash Controller

A dish lined with multiple sensors detects presence and movement of water within it. Manipulating the bowl results in liquids swirling around, and sometimes (splashing) out of the dish, which is detected by the sensors. This novel bowl is proposed for entertainment interface or to train hand-eye coordination. Splash Controller [5] builds upon embodied *skills* and leaves *traces*. The interaction mapping includes detecting tricky motor tasks such as flicking the bowl to expel water and catch it again in the dish. Spills of water are visible on people and the environment - at least temporarily. In describing this controller, it seems incorrect to speak of an interface plus water, because the controller requires the presence of water to function: water is part of the interaction itself.

We like to emphasize the potentially strong co-dependency between subject and object of the interaction by blending interface, environment and the task objective. The device should not be used to control some distant, virtual process, but add to the skillful dealing with bowls and water in some context. The challenge is to design for such situations that center on the manipulation of liquids (e.g. cleaning, cooking), instead of mapping this device to some 'digital game'.

FireFlies

Fireflies [2] supports primary school teachers in managing a busy classroom. A portable, tactile interface influences ambient sounds and four tone lighting units placed on each child's desk. FireFlies is promising because it is an open-ended design so that

teachers can explore what meanings should map to sounds and colors, fitting the tool to their own working practice. For example, a teacher could use colors to indicate which individual pupils they have spoken with, which would be scaffolding the teacher in making sense of their task by creating distributed traces of their own activity. If the main skill of a teacher is in face-to-face interaction with pupils, FireFlies provides an unobtrusive enhancement. It illustrates that CET may often be about what technology does *not* do.

The main challenge for FireFlies is that it's physical design has no inherent relation to the skillful coping of the teacher, allowing for the interpretation that Fireflies provide 'information' rather than figure in skillful tool-use. Compare this to the way in which a pupil may try to draw attention of the teacher, using the entire body for subtle (and less subtle) nonverbal invitations. Here, the 'form' of the interaction actually does work in the social coordination. This is a direction in which we would like to see FireFlies developed further.

Towards CET: design for human being

Currently we are in the start-up phase of an interdisciplinary research group using design, ethnography, theatrical enactment, and theory to develop CET. As CET will form an inherent, and intimate part of the way people give meaning to their lives, we find it crucial to use a participatory, iterative approach, collaborating with users and continuously testing designs 'in the wild'.

CET emphasizes how continuous, embodied interaction with the environment leads a person to enact a world that is inherently both social and physical in nature. CET, based on embodied theories, can help designers

and engineers to create truly integrated forms of interactive technology that neither ignore, nor replace, our embodied 'being in the world', but instead become part of the embodied way people create meaning in life.

The prospect of CET is that it allows people to be embodied in the world *through* technology [4], rather than 'stepping out' of our embodied actions to enter a 'virtual' world of digital processing, as we see happening today, whenever the phone or tablet calls.

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