Thilo Paul-Stueve (Hrsg.): Mensch & Computer 2007 Workshopband. Weimar: Verlag der Bauhaus-Universität Weimar. 2007, S. 125

Design Challenges for Wearable Computing

Markus Klann

Fraunhofer FIT

Abstract

This paper suggests a specific theoretical understanding for the concept of wearable computing. This understanding is inspired by Polanyi's theory of tacit knowledge and is also in line with a number of established theories on human-machine interaction. One way of stating tacit knowledge theory is that the capacity to carry out skilful human activities is at least partially implicit to their performance. The paper argues that the specific potential of wearable computing lies in integrating with such skilful activities and that their tacit character makes for a number of corresponding design challenges. A few major directions for addressing these challenges are outlined.

1 The tacit dimension of skilful action

The potential of wearable computing comes from the possibility to integrate closely with skilful human activities. To explain this specific potential and also the corresponding challenges for design, here is a description of how people use artefacts in skilful activities.

When we use a stick as a probe to explore an unknown area, our perception is that the tip of the stick touches the surface of the objects, conveying to us their general geometry and the texture and consistency of their surface. You can easily try this by probing the objects on your desk with a pen. Despite our sensation, what is actually available to our sensory apparatus is just the pressure exerted by the stick on our fingers. By learning to use a stick as a probe, we learn to interpret these pressure differences in terms of the object qualities we are interested in. This relation is what tacit knowledge theory calls tacit (Polanyi 1967). In the stick case it means that our capacity to interpret the pressure of one end of the stick in terms of object properties at the other end is implicit to performing the probing action. Or put differently, in the probing action we do not know the pressure and its relationship to object properties in an explicit way that we could express as parameters or rules. Tacit knowledge theory does not say that the relationship is principally inaccessible to analysis. It just says that in skilful performance the parts of the relationship are not known analytically but implicitly in the explained sense.

What this means for the use of artefacts in skilful activities is that they are appropriated in a fundamental sense. We learn to use them in the same way that we use the rest of our body. As far as the performatory capacity is concerned the artefacts become part of the body. It is in this sense that appropriately designed technology can be said to become embodied. One example for this understanding is the account of embodied interaction by Dourish (2001) who has also been referring to Polanyi's stick example. Polanyi's theory also offers an important enriching perspective on another theoretical foundation for the design of interactive systems which is Heidegger's distinction between different modes of existence for objects depending on whether they are engaged in our activities. The implications of this theory for the design of interactive systems have been described by Winograd & Flores (1986) in their seminal „Understanding Computers and Cognition: A New Foundation for Design".

Based on this understanding, the potential of wearable computing is therefore to have interactive technologies that people can integrate with their skilful activities and use with the same ease and efficiency they can learn to use their body. In this sense wearable computing may serve as an amplification of human skill and competence as opposed to a partial replacement. This notion is reflected in Mann's „Wearable Computing as means for Personal Empowerment" (1998). What we can also learn from Mann's text is that the potential of wearable computing is quite neutral as to whether we actually will turn it into personal empowerment or rather in an intricate and intimate control structure.

So there are at least two distinct design challenges for wearable computing. The first comes from the tacit nature of skilful activities, including the use of artefacts. This makes it difficult or practically impossible to fully understand a skilful activity in an analytical sense in order to deduce a design for some wearable system. Also, the prospective users cannot fully judge a design other than by integrating it into their skilful activity – a process that is likely to change both the skilful activity and the best fitting design. The second challenge is a long-term corollary of the first one. The tacit nature of skilful activities makes it even more difficult to judge whether a given design will eventually be perceived as an empowering support or as a constraining instrument of control.

It is an obviously important question for the field of wearable computing, whether there are unique design challenges requiring fundamentally different design approaches. I would argue that this is not the case. The theory of tacit knowledge does not only extend to the use of artefacts in skilful activities. It is a general theory of how human beings make use of their cognitive abilities. This means that the design challenges outlined above apply to all fields of designing information technology for skilful activities. What is specific about wearable computing is that it can be integrated closely with bodily activities, making it particularly difficult to study the context of use and how potential designs could be integrated. Conversely, the full potential of wearable computing can only be leveraged if a good integration is achieved. Design approaches for addressing the principal challenges do exist. So I would argue that the main design challenge for wearable computing consists in studying how these approaches can be applied to the specific design task and also in actually implementing these approaches in real-world development.

2 Design approaches

In his review of Polanyi's „The Tacit Dimension", Alexander (2002) says that the book should be read by every requirements engineer. The reason being that because of the tacit nature of knowledge, users of prospective systems cannot readily express many of their requirements: „Scenario workshops, prototypes and demonstrations are better for that". These techniques and the understanding that they are useful for design are of course not new. They have been part of participatory and user-centred design for many years now (Norman & Draper 1986; Schuler & Namioka 1993).

What is different and difficult about wearable computing is the close integration with bodily activities as explained above. This makes it very different from standard desktop computing and probably still substantially different from mobile computing. As a consequence, techniques for prototyping and demonstrations have to be adapted. For example, the question of device ergonomics is of great importance for the actual usability of wearable systems. An interesting approach for prototyping wearable technologies in a user-centred design process has been developed at CMU (Siewiorek & Smailagic 2002).

In a real-world design effort, all of these design approaches are applicable to varying degrees. An overview of how we tried to combine some of these approaches in the context of a large research and development project can be found in (Klann 2007).

3 Conclusions

Some conclusions can be drawn for important strands of further research.

Practice research. A better understanding of the concrete practices of people is the foundation for good design. While there are a number of approaches for studying practice, the transformatory impact of new technologies on practices still is insufficiently understood. Moreover, practices involving skilful and situated collaborative work are notoriously difficult to investigate in terms of observation and analysis, prompting new investigative techniques.

Experience design. The ability to prototype experiences of new technological concepts and assess experiential quality early on in design processes, seems like a particularly important step to explore and decide between different design directions.

Multidisciplinary Design. Specifically for the field of wearable computing integrated design involving disciplines from electrical engineering, over industrial design to fashion design and many in between seems to be crucial. The close integration of wearable technologies with the user's personal space makes deficits on any level of design disturb the overall appreciation of a system. Multidisciplinary design is extremely difficult to achieve, given the different paces, languages and even cultures of the disciplines.

Living Labs. One of the most beneficial factors to innovation is a sustainable and ecologically valid design process. If a user community can be engaged in an on-going design process with rich participation from both the users and the designers, not only can technologies such as wearable computing be designed in a fitting way but also the social context can evolve to make optimal use of the technology. Living Labs are one concept for creating such sustainable and valid environments for innovation.

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Acknowledgements

The presented research is supported by the European Commission as part of the wearIT@work project (contract no. 004216). I am grateful to all the colleagues I got to work with in the course of this project, both within my institute and outside. I am especially grateful to the EC project Relate for our collaborative research and most of all to the Paris Fire Brigade for their continued commitment to our joint work.

Contact

Markus Klann

Fraunhofer FIT, Schloss Birlinghoven, 53754 Sankt Augustin

Tel.: +49 2241 14 2152, E-Mail: markus.klann@fit.fraunhofer.de