Editorial

Eva Hornecker*

The Open University,
Milton Keynes MK 76AA, UK
and
University of Strathclyde,
Glasgow G11XH, UK
E-mail: eva@ehornecker.de
*Corresponding author

Albrecht Schmidt

University of Duisburg-Essen,
Essen 45117, Germany
E-mail: albrecht.schmidt@acm.org

Brygg Ullmer

Lousiana State University,
Baton Rouge, LA 70803, USA
E-mail: ullmer@cct.lsu.edu

Biographical notes: Eva Hornecker is a Lecturer in the Department of Computer and Information Sciences at the University of Strathclyde in Glasgow, UK. Previously, she was a Postdoctoral Research Fellow at the Pervasive Interaction Lab at the Open University, UK, and an Acting Lecturer at the University of Canterbury, New Zealand, and the TU Vienna in Austria. She completed her PhD on Tangible Interfaces as a medium for collaboration support at the University of Bremen. Her interests concern multimodal, tangible and embodied interaction, user research, design methods and qualitative research methods for understanding user interaction with 'beyond the desktop' technologies.

Albrecht Schmidt is a Professor for Pervasive Computing and User Interface Engineering at the University of Duisburg-Essen in Germany. Previously, he was the Head of Department at the Fraunhofer institute for intelligent information and analysis systems. From 2003 to 2006, he headed the embedded interaction research group at the University of Munich. He studied in Ulm, Karlsruhe and Lancaster, where he completed his PhD on the topic 'ubiquitous computing – computing in context'. His professional interests are in media informatics and ubiquitous computing, and in particular in the area of user interface engineering. He enjoys creating new interaction techniques and interfaces technologies.

Brygg Ullmer is an Assistant Professor in the Department of Computer Science and the Center for Computation and Technology (CCT) at Louisiana State University. He completed his MS and PhD in the Tangible Media Group of MIT's Media Laboratory and BS (computer engineering) at the University of Illinois, Urbana-Champaign. He held a postdoctoral position in Zuse Institute

Berlin's visualization department; internships at Interval Research and Sony CSL (Tokyo) and has been a Visiting and Remote Lecturer at Hong Kong Polytechnic's School of Design. His research interests include tangible interfaces, visualisation, computational biology, rapid physical prototyping, and computationally-mediated arts and crafts.

1 Introduction

With technological advances, computing has progressively moved beyond the desktop into new physical and social contexts. As physical artifacts gain new computational behaviours, they are able to be re-programmed, customised, re-purposed, and to interoperate in rich physical, social and technical ecologies. They also become more complex, and require intense design effort in order to be functional, usable and enjoyable. Designing such systems requires interdisciplinary thinking. Their creation must not only encompass software, electronics and mechanics, but also the system's physical form and behaviour, its social and physical milieu, aesthetics and more.

In these new contexts, tangible interaction presents a philosophy and strong interaction design alternative for many kinds of physical artifacts that incorporate or prospectively relate to digital behaviours. In the process, from technical and also conceptual perspectives, computationally-mediated interaction becomes embedded both into physical artefacts and within users' tasks.

As a design approach, tangible interaction emphasises tangibility and materiality, physical embodiment of data, bodily interaction and the embedding of systems in real spaces and contexts. One of the core ideas that has driven this area is to quite literally allow users to grasp data with their hands, fusing the representation and control of digital data and operations with physical artefacts.

Many new opportunities have also evolved from a technical perspective over the last decade, including easy means for wireless communication, increasing processing power and ease of integration, and lowering costs of diverse sensors, actuators, processors and displays. Both consumer devices (e.g. the Wii controller) as well as electronic modules and toolkits (e.g. Arduino) are widely available, and are further lowering the threshold for engaging with tangible and embedded interaction.

In addition, from a conceptual standpoint, we have witnessed researchers evolving new user interface concepts in many different directions and domains. Advances in technologies have helped enable this and illuminated the widening bounds of possibility. But also, a more profound understanding of the potential benefit of new forms of interaction has increasingly driven many of these ventures.

The new conference series 'Tangible and Embedded Interaction' (TEI, www.tei-conf.org) – first held in Baton Rouge, Louisiana (2007) and next in Bonn, Germany (2008) – has demonstrated the international interest and rich variety of work in this area. The conference has attracted a multi-disciplinary audience including artists, designers, technology builders, ethnographers and HCI specialists, even touching upon robotics and interactive buildings. For this special issue, we invited past authors and attendees (accompanied by a general call to the community) to submit articles providing insights into current developments and directions in this emerging field.

We were excited to receive a sizeable number (roughly 30 papers) of high quality submissions. In addition to the six papers in this issue, two additional accompanying articles have been accepted to follow in forthcoming journal issues. These papers were selected in an intense peer review process; each accepted paper received at least three expert reviews, and an additional meta-review by one of the guest editors.

Of these accepted papers, Fernaeus, Tholander and Jonsson discuss an ongoing conceptual shift from an information-centric to an action-centric perspective on tangible interaction. The action-centric perspective emphasises designing tangibles that allow for meaningful manipulation and control of the digital. They focus on qualities surrounding the activity of system use, including support for social and shareable use, and interpret tangible elements as resources for action.

The next two papers relate to 'Acting with Tangibles' at a more practical level. Jorda reflects on the background of the ReacTable, and discusses live music performance as an application domain where tangible and tabletop interfaces are very successful. He explains why live music performance lends itself to tabletop tangible interaction, and how this application field productively challenges research. Jorda describes the main design issues leading to the ReacTable.

In their article *Designing for Performative Tangible Interaction*, Sheridan and Bryan-Kinns discuss another area of live performance: multi-participant digital live art. This is exemplified with the uPoi, a highly portable, tangible exertion interface. The authors outline design requirements for performative tangible interaction; the application of design requirements in evaluation; and an example application toward evaluating four public exhibitions of the uPoi system, along with this system's iterative re-design.

We then continue with two papers concerning the pragmatics of building and testing tangible devices. Gill, Walker, Loudon, Dix, Woolley, Ramduny-Ellis and Hare present techniques for the rapid design and development of tangible interactive prototypes; in particular, on methods that support the prototyping of the physical interaction elements. They present empirical data from three experiments, compare tangible prototypes to software prototypes, and investigate which level of 'quick and dirty' prototyping is useful in industrial design.

Next, Panchaphongsaphak, Ullmer and Riener investigate 'contact-sensitive artefacts'. They describe the technology and several applications of a novel approach for transforming pre-existing and purpose-designed physical artefacts into contact-sensitive interfaces and installations. Specifically, they describe how attachment of a six degree-of-freedom force-torque sensor onto physical artefacts can transform them into active, computationally-mediated interfaces.

Finally, the last article contributes a conceptual, theory-oriented perspective. Price, Sheridan, Pontual Falcão and Roussos present a framework for understanding the effect of tangible technologies on interaction and cognition. They interpret tangible technologies as external representations which mediate cognition. The authors discuss the opportunities offered by tangible environments for novel representational formats and their applications within learning scenarios. An example scenario is presented to illustrate how the framework can be used as a method for investigating the effectiveness of different designs for supporting science learning.

Acknowledgements

We are grateful to all the volunteers from the community, listed below, who helped in reviewing papers and who provided valuable guiding comments:

Alissa Antle, Canada; Astrid Twenebowa Larssen, Ghana; Bart Hengeveld, The Netherlands; Beat Signer, Switzerland; Bernard Robben, Germany; Bruce Thomas, Australia; Christopher Lueg, Australia; Daria Loi, USA; Ehud Sharlin, Canada; Elise van den Hoven, The Netherlands; Florian 'Floyd' Müller, Australia; Frank Feltham, Australia; Ivan Poupyrev, Japan; Jakob Tholander, Sweden; Jean-Bernard Martens, The Netherlands; Jennifer Sheridan, UK; Johann Habakuk Israel, Germany; John Halloran, UK; Jörn Hurtienne, Germany; Luigina Ciolfi, Ireland; Mads Vedel Jensen, Denmark; Michael Rohs, Germany; Mike Fraser, UK; Monika Fleischmann, Germany; Nicolas Villar, UK; Oren Zuckerman, Israel; Orit Shaer, USA; Paul Holleis, Germany; Paul Marshall, UK; Ron Wakkary, Canada; Sara Price, UK; Sergi Jorda, Spain; Simon Holland, UK; Steve Gill, UK; Susanne Grabowski, Germany; Thecla Schiphorst, Canada; Tomas Sokoler, Denmark; Wendy Ju, USA; Wolfgang Strauss, Germany; Xiangyu Wang, Australia; Ylva Fernaeus, Sweden; Youn-kyung Lim, South Korea; Yvonne Rogers, UK.