Die Fühlbarkeit des Digitalen

form+zweck 22

English Version

Eva Hornecker

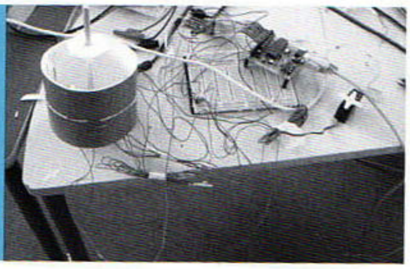
Eva Hornecker makes the case in her article for including all of the senses when digital systems are being integrated into the everyday world: multisensory interactions should help to acquire a new richness in habitual experience and several patterns for interaction. To her it is more important to achieve clarity by means of interactions between humans and machines and, to a growing extent, between humans with the help of machines, than to (merely) design objects and to optimise "tiles" or "props" which convey these interactions to devices. Eva Hornecker presented a framework on the subject of "Tangible Interaction" to the CHI (Conference on Human Factors in Computing Systems) 2006 which received much attention and participated in the organisation of the first TEI (Tangible and Embedded Interaction) for 2007 in Baton Rouge. After spending some time on research in Austria, New Zealand and Great Britain, she now works as a visiting research fellow in the Pervasive Interaction Lab at The Open University in Milton Keynes.

Tangible Interaction - An Inclusive Perspective

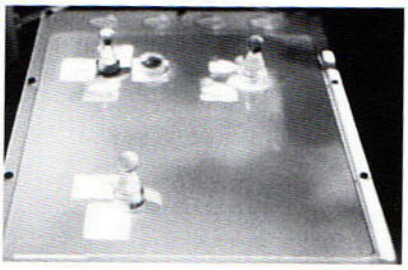
Computers are increasingly leaving the desktop – they now are embedded in our environment and into everyday objects, moving out into the world. This means that 1. computing is embedded in the physical world, 2. users can control computation through bodily movement and by interacting with physical input devices (which are not just another remote control), 3. the computers' output is integrated into the everyday world, e.g. through graphic projections or sound and with this, 4. computing moves into new social contexts, from schools over hospitals to care homes and wastewater plants. Computing enters the built environment with large displays and sensors embedded into floors and doorways; it has become prominent in museums in the form of interactive installations that provide visitors with new means to experience and explore the topics of exhibitions; it has become an intrinsic part of everyday appliances, even being integrated into everyday furniture (think of the announcement of Microsoft's new Surface table); and has moved into schools, teachers experimenting with electronic whiteboards and Lego Mindstorm Robots.

Tangible Interaction is part of this larger trend, which emphasizes the priority of the physical or everyday world, aiming to retain human situatedness in the everyday world (inspired from Mark Weiser's vision of Ubiquitous Computing[1]). The real world is not replaced, being seen as inferior, but is augmented with digital capabilities, retaining its role as our habitat.

Using tangible interaction as a design approach prioritizes tangibility, materiality, bodily interaction, and embeddedness in real spaces as principles of design. One of the core ideas that has driven this area is to quite literally allow users to grasp data with their hands, representing digital data objects and interaction tools with physical items (of which there are a great variety, including models, handles, and so on). People tend to react with immediate interest, even fascination, on encountering such systems, as tangibles seem to provide



Building interesting prototypes requires skills in visual design and craft, mechanical thinking ability, as well as with electronic wiring and programming. As a project exercise in 2004, students at the University of Southern Denmark developed 4D concept sketches (3D plus movement behaviour) for electronic consumer devices. This picture shows the prototype's internals, which need to be tugged into the device's base. A round top piece will be put on top of the base visible in the picture. Reid sensors then detect rotation of the top piece against the base.



Tangible Viewpoints[2] is a typical representative for systems that use tangible figurines to access and interact with a digital information space. The icons represent video and text snippets created by high school students about their everyday life. Moving figurines together makes elements visible that concern neighbouring figurines. Placing the glass pebble onto an icon opens the video on a separate screen.

1 M. Weiser, (1991): The Computer for the 21st Century. Scientific American 265 (3); See also P. Dourish (2001): Where the Action Is. The Foundations of Embodied Interaction. Bradford Book, MIT Press; P. Wellner, W. Mackay, R. Gold (1993): Computer-Augmented Environments. Back to the Real World. Communications of the ACM 36 (7), p. 24-26 2 A. Mazalek, G. Davenport, H. Ishii (2002): Tangible viewpoints: a physical approach to multimedia stories. Proceedings of International Multimedia '02. New York: ACM.153-160 3 E. Hornecker, J. Buur (2006): Getting a Grip on Tangible Interaction: A Framework on Physical Space and Social Interaction. Proc. of CHI 2006. ACM: N.Y., pp. 437-446; E. Hornecker: Die Rückkehr des Sensorischen: Tangible Interfaces und Tangible Interaction, in: H.D. Hellige (ed.): Engpass Mensch-Computer-Interface. Historische, aktuelle und zukünftige Lösungsansätze für die Computerbedienung. Transcript Verlag (in press); B. Ullmer, A. Schmidt, E. Hornecker, C. Hummels, R. Jacob, E. van den Hoven (eds.): Proceedings of 1st International Conference on Tangible and Embedded Interaction 2007 (TEI'07). ACM: N.Y. 4 H. Ishii, B. Ullmer (1997): Tangible Bits. Towards seamless interfaces between people, bits, and atoms. Proceedings of CHI'97, ACM: N.Y. , pp. 234-241; B. Ullmer, H. Ishii (2000) Emerging frameworks for tangible user interfaces. IBM Systems Journal 39(3-4), pp. 915-931 5 Jacob Buur, personal communication 6 M. V. Jensen, J. Buur, T. Djajadiningrat (2005): Designing the user actions in tangible interaction. Proceedings of 4th decennial conference on Critical computing: between sense and sensibility. ACM: N.Y., pp. 9-18; T. Djajadiningrat, S. Wensveen, J. Frens, K. Overbeeke (2004): Tangible products: redressing the balance between appearance and action. Personal and Ubiquitous Computing, Vol. 8 No. 5, pp. 294-309; C. Hummels, K. Overbeeke, S. Klooster (2006): Move to get moved: a search for methods, tools and knowledge to design for expressive and rich movement-based interaction Personal and Ubiquitous Computing. Special issue on Movement-based interaction (in print) 7 B. Bongers (2002): Interactivating Spaces. Proc. Symposium on Systems Research in the Arts, Informatics and Cybernetics; S. Rubidge, A. MacDonald (2004): Sensuous Geographies: a multi-user interactive/responsive installation. Digital Creativity Vol 15, No. 4, pp. 245-252; T. Schiphorst (2007): Really, Really, Small: The Palpability of the Invisible. Proceedings of CC07, Creativity and Cognition Conference, ACM: N.Y., pp. 298-301.

a counterbalance to the increasing virtualisation of our everyday world, re-introducing the sensuality of the haptic, and providing an opportunity for whole-body interaction. While this immediate appeal is evident, it is less clear what may be the best application areas – too many of the examples in the literature only exist as demos and conceptual prototypes.

Yet moving from toy examples and "proofs of concepts" to real applications in real contexts requires the accumulation of design knowledge together with serious evaluation. To design good systems, we need to know what makes up the "user experience". Understanding this requires interdisciplinary research, since the user experience is influenced by the physical interface, the software inside the system, the interactions between these and furthermore by the context of use. The dividing line between the domains of computer scientists, mechatronics experts, and the concerns of product and industrial designers has become fuzzy, with household appliances containing chips, displays, and even actuators that make them move.

The Clavier is a spatial sound installation (developed as a student project at the University of Bremen, 2004, Medieninformatik bachelor degree program): Visitors to a nightly public festival in a park dance on the Clavier, triggering drums and beats along with coloured light whenever they pass a small sensor. People interact within the interface that surrounds them, their whole body becoming an interaction device. Tangibility here has shifted into the physical surrounding and the users' bodies. Interaction is highly visible, supporting coordinated and shared production of sound effects.

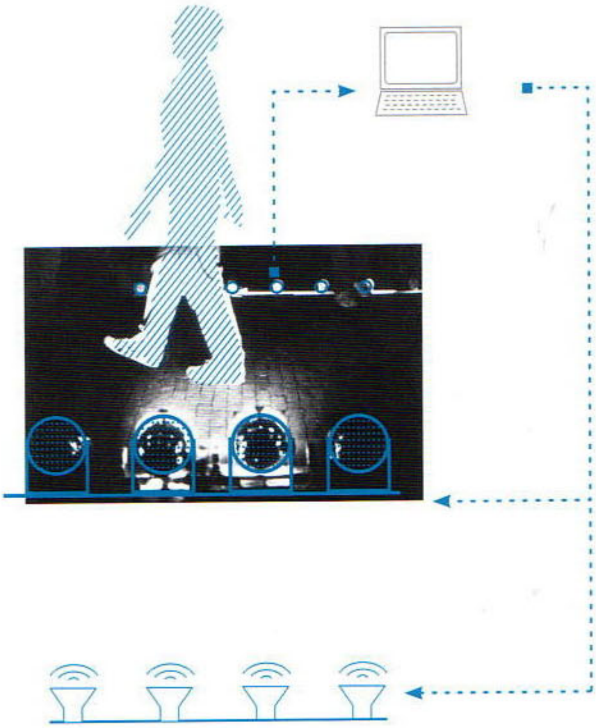
Scaling up from toy examples requires mastery of complex behaviour as well as the creation of rich interactions suitable for the context of use. Thus an interdisciplinary perspective is needed to understand tangible interaction and to create good products.

Tangible Interaction as a strategic umbrella term

What is tangible interaction? Using this term has served to provide an encompassing viewpoint, easing collaboration and emphasizing commonalities across disciplines.[3]

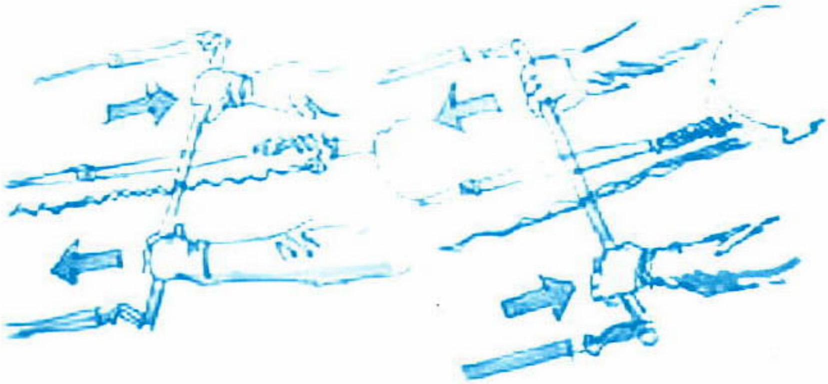
In computing and human-computer interaction, this author's initial fields, the terms "tangible media" and "tangible user interface" (TUI)[4] have been in use since the late 90s to describe systems that share characteristics with work from product design aimed at creating rich physical interactions. Yet the definitions used to describe tangible user interfaces were too restrictive to apply to related areas – the definitions focussed on providing tangible "handles" (physical pointers connected with the items interacted with) to support manipulation of digital data, substituting graphical with tangible interfaces (data-centered view). Many of the systems developed under the TUI label employ tangible figurines and tokens with visualized data floating around them, quite literally indicating that the tangible objects mainly serve as an entry point into a digital data space.

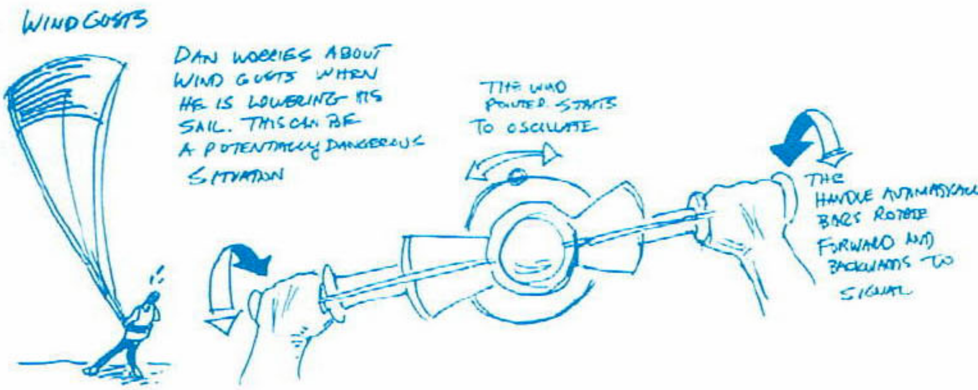
Interpreted as a rhetorical device in the context of technology trends at that time, this definition marked tangible interfaces as an antithesis to graphical user interfaces and virtual reality. As a side effect, this put the emphasis on the control of data, whereas an alternative interest might be in controlling the real world (e.g. a heating controller).[5]



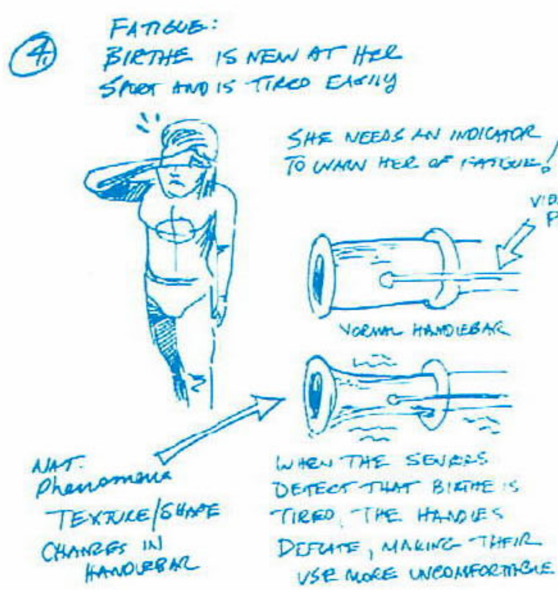
Or we might want to create completely new interaction styles, having to start thinking about the interactions and actions involved, before deciding upon a digital model or on a physical form.[6] This perspective focusses on bodily movement and aims to support rich expression and to enhance physical skills (instead of replacing these with button pushing which is less versatile in terms of bodily skills).

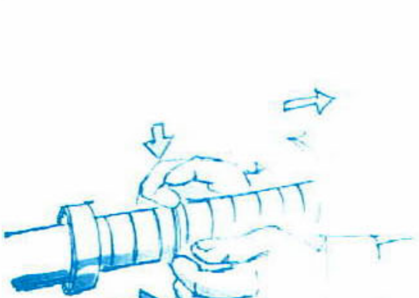
From the arts world, a space-centered view can be identified, emphasizing the creation of interactive and reactive spaces where computing as well as tangible elements are means to an end, rather than explicit aims.[7] The bodily movement of the "spectator" (who becomes an actor and performer) comes to be an integral part of the art installation, sometimes relying on bodily self-perception (invisible to the outside spectator). These types of art installations are often characterised by involvement of the whole body of the spectator, turning it into the means of interaction.





Movement studies of windsurfers and a subsequent product design for an intelligent handlebar (iBar) that acts as safety device monitoring performance, physiology and environment: It gives warning of obstacles, water depth, dehydration, fatigue, speeding, etc. The design reflects values of surfboarders, provides meaning by alluding to natural phenomena, and makes use of reflexes that users display in their surfing practice. The bar can vibrate and the handles deform to alert of dangers, in the middle there is an inflatable display.[8]





Traditionally engineering and computing have seen the interface as distinct and secondary to the functionality incorporated in a system. The interface is placed between the software and the user, enabling access to its features. Replacing one interface with another only changes the surface while the basic interaction process stays the same. Using the term "tangible interaction" places the focus on the design of the interaction instead of the visible interface, enabling us to discuss qualities of the interaction, and to focus on what people actually do with the system.[9]

This encompassing perspective emphasises tangibility and materiality, physical embodiment of data, bodily interaction, and the embedding of systems in real spaces and contexts. Systems may very well combine graphical with tangible elements – there is no inherent conflict between the two if we no longer treat tangibility as antithetical.

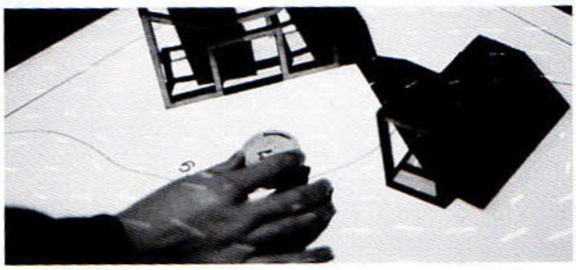
History and Precursors to Tangible Interaction

In 1993, a special issue of the Communications of the ACM with the programmatic title "Back to the Real World"[10] argued that both desktop computers and Virtual Reality estrange humans from their "natural environment" and require too much translation work between real and digital worlds. Instead, one should augment and enrich the real world with digital functionality. Whereas the field of Human-Computer Interaction so far had been dominated by cognitive science, viewing humans as "information processors", now ideas from ethnography, situated cognition, and phenomenology became influential in the argumentation for Augmented Reality and Ubiquitous Computing: „humans are of and in the everyday world".[11]

While the underlying ideas for tangible user interfaces had been discussed in this special issue, it took a few years for these to evolve into an interface concept in its own right. In 1995, Fitzmaurice, Ishii and Buxton introduced the concept of a "graspable interface",[12] using wooden blocks as graspable handles to manipulate digital objects. A block is anchored to an object on the monitor by placing it on top. Graspable handles in combination with functionally dedicated input tools were argued to distribute input in space instead of time, to support bimanual action and to reduce mediation. Ishii and his students presented a more encompassing vision of "Tangible Bits" in 1997.[13] The idea was to turn the whole world into an interface by connecting objects or surfaces with digital data and to present information with "ambient displays". The emphasis lay on creating rich multi-sensory experiences that honour human dexterity. Ishii's work focused on using tangible objects to both manipulate and represent digital content. While the graspable blocks were frequently reconnected and thus were abstract, iconic appearance of tangibles was now emphasized.

For most of the following decade research focused on developing systems to explore technical options. In recent years, the proof-of-concept phase has led on to a more mature stage with increased emphasis on conceptual design, user and field testing, critical reflection, theory, and building of design knowledge. Connections with related developments in the design disciplines became stronger, motivating the recent move towards a broader understanding of the field as "Tangible Interaction".

Several less well known precursors to the work of Ishii and his students have influenced the field. These addressed issues in specific application areas such as architecture, product design, and educational technology; the ideas being picked up by HCI researchers as a new interface concept to be systematically pursued. Probably the first system that can be classified as a tangible interface was Perlman's "Slot Machine", which uses physical cards representing language



Ishii's Urp system[16] for urban planning enables interactive simulation of the effect of building placement on sunlight and wind flow. The tangible models of two buildings cast (digital) shadows. Simulated wind flow is projected with white lines onto the surface. Somebody places a wind probe onto the lines to see its strength. Tangible and digital elements here augment each other nicely, the shadows following the buildings in realtime if these were moved about. Not pictured here is the clock tool that changes the time of day and affects shadows and other tools, e.g., for changing surfaces of buildings between glass (creating sun reflections) and stone.

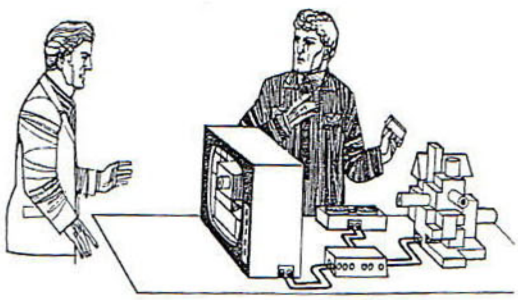
constructs to program the Logo Turtle.[14] Sequences of cards could be inserted into slots of the machine, creating complex commandos such as "move forward twice".

In the early 80s both Aish and Frazer were looking for alternatives

8 Ken Zupan (2005): Using Natural Phenomena to Create Product Attachment between Human and Machine. Masters thesis in IT-Product Design, University of Southern Denmark 9 See e.g.: T. Djajadiningrat, S. Wensveen, J. Frens, K. Overbeeke (2004): Tangible products: redressing the balance between appearance and action. Personal and Ubiquitous Computing, Vol. 8 No. 5, pp. 294–309; J. Grudin, (1990): Interface. Proceedings of CSCW'90. N.Y.: ACM, pp. 269-278 10 P. Wellner, W. Mackay, R. Gold (1993): Computer-Augmented Environments. Back to the Real World. Communications of the ACM 36 (7), pp. 24-26 11 Weiser, M. (1993): Some Computer Science Issues in Ubiquitous Computing. Communications of the ACM 36 (7), pp. 74-84 12 G.W. Fitzmaurice, H. Ishii, W. Buxton (1995): Bricks: Laying the Foundations for Graspable User Interfaces. Proceedings of CHI'95, N.Y.: ACM, pp. 442-449 13 H. Ishii, B. Ullmer (1997): Tangible Bits. Towards seamless interfaces between people, bits, and atoms. Proceedings of CHI'97, pp. 234-241 14 Perlman, R. (1976): Using Computer Technology to Provide a Creative Learning Environment for Preschool Children. MIT Logo Memo #24 15 R. Aish (1979): 3D Input for CAAD Systems, Computer Aided Design 11 (2), pp. 66-70, Also: R. Aish, P. Noakes, P. (1984): Architecture Without Numbers. Computer Aided Design 16 (6), pp. 321-328; J. Frazer, J. Frazer, P. Frazer, P. (1980): Intelligent Physical Three-Dimensional Modelling Systems. Proceedings of Computer Graphics'80, pp. 359-370; Also: J. Frazer, J. Frazer, P. Frazer, P. (1982): Three-Dimensional Data Input Devices. Proceedings of Computer Graphics in the Building Process 16 B. Ullmer, H. Ishii (2000): Emerging Frameworks for Tangible User Interfaces. IBM Systems Journal 39(3-4), pp. 915-931

to the then clunky and cumbersome CAD systems in architecture, wanting to enable the future inhabitants of buildings to partake in design discussions with architects, to make interaction with CAD more intuitive, and to support rapid idea testing.[15] Both developed systems for "3D modelling" where users build a physical model from blocks provided, the model then being scanned and interpreted by a computer. Users can configure the digital properties of blocks and let the computer calculate floor space, water piping, or energy consumption. The simplest systems used an electronic breadboard grid that one would plug components onto. Frazer's "Intelligent Modelling Technique" was used in an experiment on CAD use by home self-builders. Residents in Lewisham Borough, London, built their homes following the so-called Segal approach using Frazer's construction toolkit.

Often mentioned as inspiration for the notion of Tangible Interfaces are the works of product designer Durrell Bishop.[17] He designed a "Marble Answering Machine" as a concept sketch at the Royal College of Art. Incoming calls are represented with coloured marbles that roll into a bowl. Placed into a second bowl, the messages are played



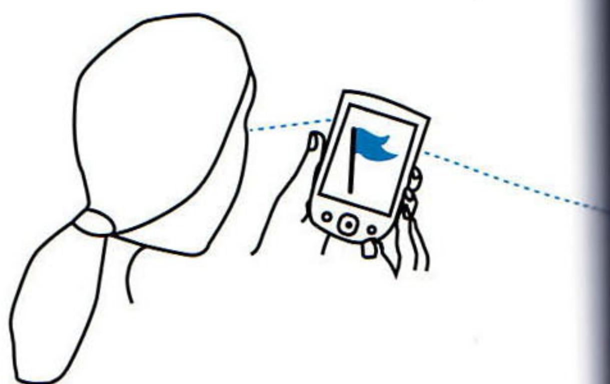
Frazer's vision of an intelligent 3D modelling system that scans a physical construction from connecting blocks, interprets it and creates a digital model that can be analysed for various aspects. (picture from Frazer et al 1980)

back. Putting a marble onto the phone calls the number from which the call originated. Bishop's designs rely on physical affordances and user's everyday knowledge. Most striking is how his works assign new meanings to objects (object mapping), turning them into pointers to something else, into containers for data and references to other objects in a network. Many of his designs further employ spatial mappings, deriving meaning from the context of an action (e.g. its place). A design sketch has a radio mounted in front of a poster. To change channels one moves the radio on its railings. What Bishop succeeded with in his designs, using known objects as legible references for the aesthetics of new electronic projects while refraining from simplistic literal metaphors, playfully recombining meanings and actions, has remained a challenge and inspiration.

Studying social interaction around tangible environments

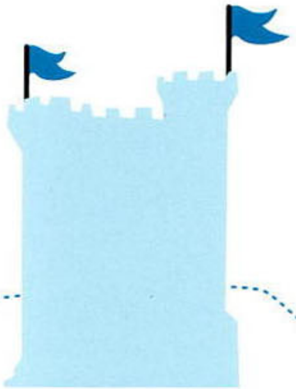
One area where tangible interaction has clear advantages is in the support of social interaction and collaboration. From the very start, an underlying aim of many systems in this area had been to foster dialogue between domain expert (such as architects) and concerned parties (future inhabitants of buildings) and to support interactive dialogue in general (cp. the discussion of Aish and Frazer's work). Supporting social interactions therefore has been the focus of my own research in recent years. A central theme of this research is the interweaving of the material and social aspects of interaction.

The user experience with hybrid environments (coupling physical and digital elements) is influenced both by the physical elements (physical space, physical objects and their configuration) and the digital functionality. Together, these influence social interaction patterns, making certain behaviours more likely by inviting or demanding them, and discouraging other behaviours. The size of the Clavier (a spatial audio installation that one interacts with by walking along a path) affords and requires multiple users to collaborate in order to create



an interesting soundscape. Observations in the Technical Museum in Vienna[18] revealed that specific setups and types of interactive installations in a museum attracted particular use patterns. Some installations were being used mostly by individuals, other by pairs, and some tended to be surrounded by small groups. Tangible manipulation, that is the movement of objects or full-body movements, tends to be visible for others, who can learn from observing, and participate as bystanders (by for example commenting on the action), or decide to take an active part, waiting for an appropriate moment to join. Tangible interaction, by virtue of being visible, thus becomes performative – the dance on the clavier is unnecessary from a purely technical perspective!

17 R. Abrams (1999). Adventures in Tangible Computing: The Work of Interaction designer 'Durrell Bishop' In Context. Master's thesis, Royal College of Art, London. R. Poynor (1995). The Hand That Rocks the Cradle. ID Magazine May/June. 60-65. 18 E. Hornecker, M. Stifter (2006): Learning from Interactive Museum Installations About Interaction Design for Public Settings. Proceedings of OzCHI'06, ACM, pp. 135-14 19 J. Halloran, E. Hornecker, G. Fitzpatrick et al. (2006): The Literacy Fieldtrip: Using Ubicomp to Support Children's Creative Writing. Proc. Of Interaction Design and Children, ACM: NY, 17-24



The physical environment in which the system is embedded influences how people interpret what they encounter - it sets the stage. For example in a technical museum visitors know that there will be some exhibits which are designed to be hands-on, whereas in an art museum they hesitate to touch anything. When evaluating a museum exhibition with a range of interactive installations it was amazing how visitors tended to distinguish hands-on exhibits and traditionally displayed objects from afar, walking straight up to the former. The surroundings contribute meaning and atmosphere. One of the tricky issues for design is whether to support, to augment, or to contravene what is already there. The sound of the clavier and the lights had been chosen to augment the nightly atmosphere of a public garden, adding mystery and wonder. On getting to know the location of Chawton House, a historic estate in South England, the research team decided to direct visitors' attention towards taking notice of their surroundings, inspiring their imagination - all with as little information-push as possible.

[Eva Hornecker]

Experimental fieldwork research (part of the EPSRC Equator project) at Chawton House on using mobile devices to support learning about and in a historic environment. Use of the device is embedded into the physical context, the device being secondary to the overall experience, information and prompts for activities being encountered while exploring the area. The design aims to direct attention towards the surrounding, instead of channelling it away from it (as often seen with electronic guide systems).[19]

Conclusion

Tangible interaction design is already happening nowadays in areas that we are not used to thinking of in terms of hi-tech development: museum installations, toys, remote controls, kitchen and entertainment devices... the list goes on. Digitally enhanced environments and intelligent objects are becoming a reality, supported by rapid technical advances. Too often, these are governed by techno-centric visions, designs are oriented by design patterns from desktop computing (buttons or drag and drop) or traditional design thinking that emphasises visuals and form over behaviour and interaction. An encompassing perspective on tangible interaction can help us to shape this development, making use of the new options while retaining the intimate connections we as humans have with our own bodies and the physical environment.