Tangible User Interfaces in Context and Theory

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Abstract
Tangible User Interface (TUI) research has become increasingly widespread over the past 25 years. It is an essential component of Ubiquitous Computing and Augmented Reality research. It introduces many challenging problems in the theory and practice of interaction design. However much day-to-day research is concerned with the practicalities of making these systems work. In this workshop, we focus on the analytic and generative theories of TUI use, and the ways in which these can be applied to the design and evaluation of TUIs in real contexts.

Keywords
Tangible user interface, ubiquitous computing, augmented reality

ACM Classification Keywords
H.5.2 User Interfaces I.3.6 Interaction techniques

Introduction
Tangible User Interfaces (TUIs) are those in which physical objects are used to represent and control computational abstractions. Although keyboards and mice are undoubtedly physical objects, TUI research seeks further alternatives. In particular, it is concerned with the possibility of extending user interaction beyond

the virtual objects (icons and so on) that appear on a computer screen under the control of conventional UI devices.

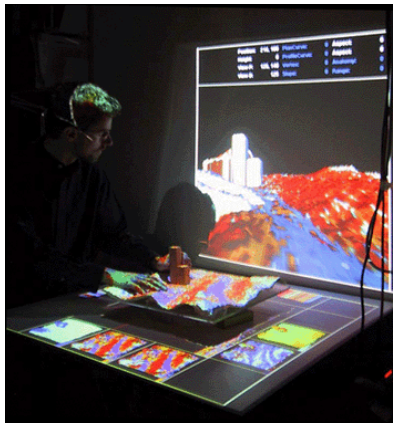

figure 1. Illuminating Clay in use

The earliest TUI systems, such as Aish's Building Blocks [1] used physical elements to represent physical designs – a literal correspondence between the interface and the represented information. This kind of application has persisted, but with substantial augmentations to superimpose digital information onto the physical layer, as in the landscape simulations of Illuminating Clay [12]. A related style of interaction augments existing information objects (especially paper) by projecting further digital displays onto them, as in the Digital Desk [16].

Alternatively, TUIs can be interpreted purely abstractly, either as manipulation devices that offer far more degrees of freedom than a mouse (e.g. Fitzmaurice's Bricks [8]), or as objects that are related together to form diagrammatic structures around tangible nodes (e.g. Ishii and Ullmer's metaDESK [11]). Tangible elements can even be used to form the syntactic elements of programming languages, either by mapping conventional language elements onto physical objects to make them more approachable [14], or integrating novel computational models into the physical environment to configure and script its behaviour, as in Blackwell's MediaCubes [3].

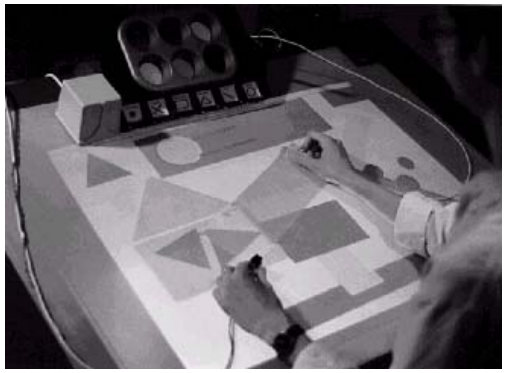

figure 2. Bricks in use

Significance of TUI research

Research into TUIs is a critical component of future developments in Ubiquitous Computing and Augmented Reality. It is clear that office-based interaction paradigms, refined through many generations of TTY and WIMP interface, are no longer appropriate when computation is distributed more liberally through the physical world. However the familiarity of our established HCI paradigms and metaphors can make it difficult for us to return to first principles of user interaction when faced by the creative opportunities of new technology [2]. The virtual world of the "desktop

metaphor" is so familiar to students and developers that it can be hard to escape. We must remind ourselves that the "windows" "objects" and "pointing" of the screen are not real. Despite the imaginative inventions of the modern GUI, the tangible aspect of user interface has scarcely changed. Keyboards acquired a few control keys, screens are a little more portable, and the mouse has evolved only slightly in 30 years. They are an effective interface for a knowledge worker at a desk. But to address other activities, and other contexts of use, we must consider alternative mechanisms for control and user feedback.

TUI research provides us with a general framework for thinking about all the situations in which objects in the physical world might be augmented, so that they can be used to manipulate or correspond with computational abstractions [7]. TUIs also provide us with a fascinating opportunity to rethink human engagement with physical objects, for example in mediating social interaction or as external cognitive resources. TUIs promise to exploit sensory channels that are otherwise neglected in HCI, and to allow rich and dextrous skilled interaction. All of these considerations engage with difficult theoretical questions about situated interaction, responsiveness, embodiment and context.

These are not questions that can be solved by applying existing bodies of theory, and certainly fall well outside the traditional bounds of computer science. But building TUI research prototypes is also technically challenging. Sensors are noisy, networks fail, and materials are not uniform. The physical world is more constrained than the possible behaviour of 3D animations (for example, few TUIs support a reset operation that returns all physical objects to their initial state). However, even where the required behaviour of a TUI is technically feasible, researchers must struggle with reliability and repeatability to make working prototypes. If these are to be deployed and evaluated in context, there are even greater challenges (varying lighting and electromagnetic conditions, manufacturing costs, physical robustness, even sufficient battery power to keep working during evaluation). If the TUI is a component of a larger UbiComp or AR system, all of these problems are compounded by conventional computing challenges arising from the use of advanced algorithms and novel distributed system protocols.

Aspirations for this workshop

In the face of these substantial technical challenges, it might be considered sufficient for a researcher simply to make a novel TUI that works at all. Nevertheless, we aspire to more. We believe that TUI research should not consist simply of a stimulating design concept followed by the hard slog of engineering work to achieve a working demo. This workshop is an opportunity for researchers to set aside the technical challenges of that day-to-day research, and "step away from the workbench" to reflect on the goals and context of our research.

We believe that it is essential to maintain research focus on the development of theoretical approaches suitable for generative design work and analytic evaluation [6,13,15]. It is also essential to understand these theories in practical contexts of use, derived from real requirements and situations. Work in collaboration with commercial product organizations is a valuable opportunity to achieve that focus.

Finally, there is little sense in developing TUIs in isolation, where they are little more than toys or laboratory demonstrators. Because TUI research is so fundamentally concerned with engagement in the real physical world, TUIs must be understood in context, both social and embodied [4,5]. At this workshop, it is the joint consideration of theory and context that we expect to produce the most stimulating outcomes.

Workshop website

www.cl.cam.ac.uk/conference/tangibleinterfaces/

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