Material-centered design and evaluation of tangible user interfaces

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Material-Centered Design and Evaluation of Tangible User Interfaces

Tanja Doering
Pervasive Computing and User Interface Engineering
University of Duisburg-Essen, Germany
tanja.doering@uni-due.de

ABSTRACT
This paper presents an overview of an ongoing doctoral research project on materiality and tangible user interfaces (TUIs). The aim of the thesis is to address materiality as an important design element of tangible user interfaces and develop a material-based design knowledge for TUIs, e.g. in the form of material-based design patterns and evaluation methods. This is done iteratively in three steps: (1) compilation of interdisciplinary material theories and their application to tangible user interfaces, (2) exploratory prototyping of material-based interaction, and (3) validation of developed design knowledge and evaluation techniques in evaluations of TUI prototypes in different application domains.

Author Keywords
Tangible user interface, material, material-centered interaction, material iconography, material culture, analysis.

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
An important quality of tangible user interfaces is the materiality of the objects used for the interaction. However, the meaning of material qualities for tangible user interfaces has yet not been explored and investigated sufficiently. Since the technical realization of TUI prototypes still is challenging and there is no guide on how to choose appropriate low-tech materials for interaction, the material selection –especially within engineering disciplines– often is based on easy availability and technical aspects rather than anticipated user experience. However, a big potential of tangible user interfaces is that they take advantage of materials and form for interaction. From a design perspective, form factors have been discussed as important features of TUIs [2]. Discussions on using material properties for designing tangible user interfaces have just started (e.g., [4]). Yet, there do not exist structured approaches for designers and engineers how to use material properties and cultural material knowledge to construct meaningful, intuitive and, appropriate tangible user interfaces. This doctoral research work in progress addresses this issue and investigates how TUI-relevant design knowledge on material properties and material semantics can be derived and then guided into material-centered methods for design and evaluation of tangible user interfaces.

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INTERDISCIPLINARY MATERIAL THEORIES
Currently, debates on the importance and the value of materials take place in many trans- and interdisciplinary contexts. From the potentials of novel and smart materials developed in engineering and material sciences to an "associative material mind" [6] applied in architecture and design to the relatively young significance of material usage in art [7] or the claim of a "material turn" as part of the cultural turn in cultural studies [4] materiality is an ongoing and vivid topic. Tangible user interfaces is a further field of research that stresses the importance and potentials of materiality for interactions between humans and computers. Thus, tangible interaction should be examined and discussed in the context of results from material discussions from other disciplines. Based on literature review and expert interviews, this doctoral research projects collects material knowledge from art history, architecture, ethnography and material sciences and puts it in relation to existing frameworks and methods from product design (e.g., [1]) and computer science.

In a first literature study, methods from material culture (e.g., [3]) and art history (e.g., [7]) were examined. In order to better understand meaningful material usage for tangible user interfaces the following questions were addressed:

- *Material Mind:* How can we integrate a collective "material mind" into design knowledge for tangible user interfaces?
- *Material Properties:* How can we better understand material properties for meaningful and context adequate interaction?

- *Material Mapping:* How does the used material relate to the linked digital data and what mappings are useful?

The analysis led to a first structured approach to guide material-centered analysis of tangible interaction (see Figure 1) and future work will include developing this further into a generative framework.

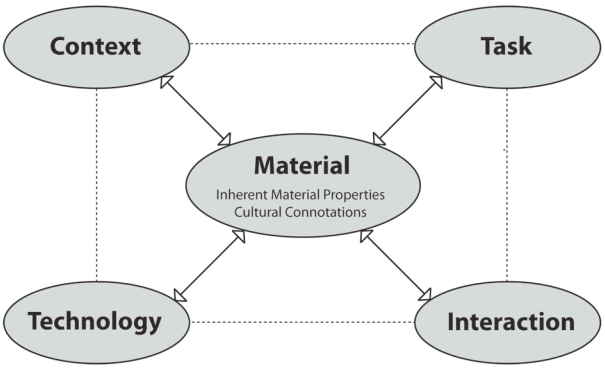

Figure 1: A structural approach for a material-centered analysis of TUIs derived from material culture and material iconography. Inherent material properties and cultural connotations are interpreted regarding (a) the context of use, (b) task, (c) interaction, and (d) technology.

TOWARDS MATERIAL-CENTERED METHODS FOR TANGIBLE COMPUTING

After "taking a step back" and examining the landscape of material theories and methods, the derived criteria are applied in a structured analysis of existing tangible user interfaces regarding used material qualities and designed interaction techniques. This is currently being done by applying the developed approach (see figure 1) to a collected comprehensive catalogue of TUI prototypes, presented in exhibitions or published on scientific conferences. This is expected to lead into a deeper design knowledge on how to use materials for tangible interaction, e.g. in the form of material-centered interaction patterns that support designers and engineers in material selection.

VALIDATION: PROTOTYPING AND IN-SITU EVALUATIONS

Based on solid theory work, practical parts of this thesis will include material-focused prototyping of TUIs, and furthermore, in order to validate the developed design concepts, their application and material-centered evaluation in concrete application domains (e.g., therapy/play, work context, home context). This could, for example, be achieved by comparative studies, but furthermore, will need specific refinements of existing evaluation methods, e.g. regarding the measurement of user experiences with different materials. Among first exploratory prototypes is the soap bubble user interface [5], a TUI that uses soap bubbles for human-computer interaction and, in this case, employs an extreme and unusual material with specific material properties to define and constrain interaction techniques, among which were gently touching, blowing, or waving hands to move a soap bubble (see figure 2). The material-focused approach led to a concept for ephemeral user interfaces: UIs that can be created when needed, but only last for a short time.

SUMMARY

The central question of this thesis is: *What can interaction design and engineering learn from interdisciplinary material theories and methods for the design and evaluation of tangible user interfaces?* And, in more detail: *how can we integrate knowledge about a material mind, material properties, and material mappings into design knowledge for tangible user interfaces?* Results are derived from three iterative steps (1) theory compilation through literature review and expert interviews, (2) explorative material-focused prototyping, and (3) validation of derived design guidelines and methods in in-situ evaluations in different application contexts.

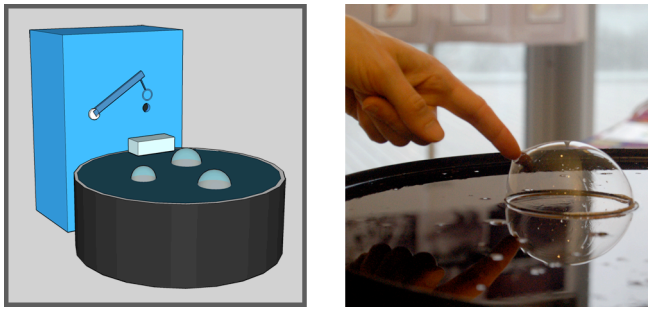

Figure 2: The soap bubble user interface: an ephemeral user interface. Setup (left) and one of the realized material specific interaction techniques (right).

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