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Transitive Materials

Towards an Integrated Approach to Material Technology

Abstract The paradigm of ubiquitous computing has for some time attempted to blur the boundaries between computation and material practice. However such distinction still exists and suffers from lack of functional transparency. Rejecting strategies which consider computation as an independent add-on operational layer, we seek to promote and emphasize the integration of novel materials and material technologies as elements revoking the gap between artifact and gadget, and between disciplines that have traditionally stood apart. We identify such materials as *Transitive Materials*, in that they are able to create and contribute to truly ubiquitous and cohesive computational systems extending invisibly across different scales of function and context. We focus on challenges and implications inherent in creating ubiquitous interaction via the augmentation of materials and structures, and addresses the design (architecture, fashion, textiles) and scientific (ubicomp, wearables, computation, materials) disciplines to support cross-disciplinary discussion of scenarios and methodologies for ubiquitous computing applications mediated by transitive materials that integrate form, function, and computation.

Keywords Ubiquitous computing, interaction design, architecture, wearable systems, fashion, smart materials

1 Introduction

The domains of architecture, product design, fashion and ubiquitous computing are rapidly converging. Shape-changing polymers, parametric design, e-textiles, sensor networks, and intelligent interfaces are now positioned to provide the underpinnings of truly ubiquitous interactivity. Seamless and effective integration will determine our ability to create more meaningful environments that respond to our personal activities and social needs. This paper attempts to define the conceptual and technical foundations for *transitive materials* – a design approach facilitating the integration of material technology in the context of ubiquitous computing.

Working Definitions We shall outline the workshop itself with a set of working definitions, and in the process provide a framework for the discussions we hope to achieve. Smart materials, in contrast to most materials, can significantly alter their properties in a controlled fashion using appropriate stimuli. On the other hand, composite materials interleave distinct materials to achieve properties unavailable in their constituents, leading to applications as unique and esoteric as interactive foods and utensils [3]. Lastly, computationally-enabled materials change their properties in response to input, but use computation to determine the output rather than responding blindly [5]. The differentiating factor between the two is the intrinsic capability for behaviors [6], allowing for great granularity of control and interactive actuation.

Within this framework, we introduce the notion of *transitive materials*. Combining the transient qualities of smart composite and computational materials, the final product has the possibility to function as frame, skeleton, sensor, actuator and/or processor. The multifaceted nature of transitive materials provides a link between computational devices and physical material elements. Today, computation remains an entity of information which is overlaid on top of the passive physical world. Transitive materials contribute to the blurring of such boundaries by allowing for, and foregrounding the generation of integrated structures that are themselves capable of input/output, computation, and ultimately of interactivity and personalization.

2 Transitive Materials: Impacts and Instantiations

The use and application of transitive materials for ubiquitous computing carries significant potential for the development of novel methods and approaches in the design disciplines. In analyzing the range of possibilities, we have identified several

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focal themes of application which realize the full vision of ubiquitous computation.

Material Computation in Architectural Design Computational media are traditionally associated with phases of production and materialization, but seldom become integral to the design processes. Generative design approaches facilitate an integrated approach to design assimilating analog material properties with digital applications in the early stages of design. Such approaches generally support the integration of material, structure, and form as inseparable parts of the design process as they may relate to matter, performance and geometry respectively [4]. In this spirit, transitive materials may be experimented with as material organizations containing computation(s) and/or promoting unique digital fabrication methods as elements inherent to their properties and behavior as explored in the early stages of design generation.

Electronic Textiles Electronic textiles are textile substrates that incorporate capabilities for sensing, remote communication, power transmission and computation, drawing upon construction methods and techniques such as weaving, embroidery, and printing [1]. While they require the reliability and physical integrity of circuit boards, they must also carry the resilience, malleability, and textural affordances of textiles that naturally conform and adapt to the body [2]. The methodologies and technologies developed in e-textiles can largely inform the development of *transitive materials*, which can seamlessly extend from on-body to large scale interactive structures necessitating a wide range of physical properties and material behaviors.

Design: Changes in Affordances Transitive materials dramatically influence the way in which we interact with and perceive objects or the environment. At the same time, such technologies carry potential towards restoring the affordances that were lost in the transition from atoms to pixels. Richness in textures and shapes, as well as the ability to support subtle background interactions become possible once we let go of the confines of traditional input and output devices.

End User Design and HCI Omnipresent, non-GUI, effectively invisible interfaces demand new modes of interaction, control, and personalization. Such personalization must not only be simple, but also highly application-dependent in order to be able to cover both the highly specific placements of transitive materials, and the basic limitations of human capability to manage such information [6]. Additionally, as structures, spaces, and objects become more malleable, we must consider newfound opportunities in refining the form and function of objects and spaces to its users.

Ubiquitous Computing: The Fabric of Reality The history of material science is a testament to the innovative ways in which humans interact with the environment [7]. The relevance of ubiquitous computing to material science is enormous, and an urgent need exists for the integration of the physical and the digital. As we explore the concept of transitive materials, an understanding of their capabilities in the context of ubiquitous applications may nurture an integrated approach to material technology and offer a new sensibility for “smart design”.

3 Organizers

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