Computational Composites

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ABSTRACT
This research project sets out to make digital technology available to architects in a way that enable them to use it as a material in design. I propose to see digital technology as a material, which acquires material properties only when it is part of a composite of two or more materials. I will investigate the value of the proposal, through a theoretical inquiry of digital technology, through experimentation with new computational composites and, finally, through a series of workshops with architects. Inspired by the vision of ubiquitous computing, the project is an attempt to propagate digital technology to other design disciplines.

Author Keywords
Ubiquitous computing, physical computing, design material, digital architecture, composites.

INTRODUCTION
In the paradigm of ubiquitous computing the computer should not just be pervasively available; it should be weaved into the fabric of our everyday life [6]. This principle has fostered ideas of *literally* weaving computers into the fabrics and materials that we use and with which we surround ourselves [1, 3–5]. Continuing this line of thought I have found it interesting to investigate how computer technology could play a role in architecture, not as a tool in the design process, but as an element in the completed buildings. It seems likely that such a form of technology would challenge the physical constraints inherent in architectural design. It might render boundaries flexible and thus enable new infrastructures and new types of spaces even new aesthetic expressions. Whether this is the case is not, however, within my scope of expertise. The role for the computer scientist would be to assist the architect in a manner analogous to how engineers assist architects in other material questions. The architect must know the material to suggest designs using it. Architects spend a vast amount of time studying new materials. They study materials' functional and aesthetic qualities such as their strength, their ability to resist potentially damaging climate effects, their aging process, their possible composites, etc. These properties work as a way to both inspire and limit the architectural design.

UbiComp '06 Doctoral Colloquium
September 18th, 2006, Irvine, California.

This position paper is not an official publication of Ubicomp '06.

THE GOAL OF THE RESEARCH PROJECT
The goal of this research project is to make digital technology available to architects in a way that enables them to use it as a material in their design. For that I propose to see digital technology as a material, which acquires properties as a design material only when it is part of a composite with other (physical) materials. I surmise that such an approach will bridge the gap between the, sometimes, abstract digital technology and the physical nature of architecture. Furthermore, I surmise that it will reveal a design space from which architects can derive inspiration. Therefore, the project will investigate this proposal in three steps. The first will be a theoretical inquiry of digital technology to ascertain how it exists as a design material in composites as well as in isolation. The second step will be an experimentation with computational composites, first in the manner of studying others examples of composites (e.g. with textiles [4], concrete [1] or plastic [3]) and later with my own prototypes of new composites. This step is staged to explore the properties and the limits of the design material by seeking examples of possible, extreme, and impossible composites. The last step will be to test the proposed view on digital technology together with the developed computational composites in a series of workshops with architects. I will organize the workshops around presentations of the computational composites and the general idea of digital technology as a design material and thus form an opportunity to study the architects reactions to the proposed view. In short, inspired by the vision of ubiquitous computing, this project is an attempt to take on the role of a material scientist and develop a digital technology as a design material that can propagate to other disciplines.

The remaining of this presentation will take up the first aspects of the reasoning underlying the proposal of computational composite.

WHAT IS DIGITAL TECHNOLOGY?
Obviously it is necessary to go beyond the desktop computer if we wish to convince architects that the technology holds a potential as an architectural element. But to depict digital technology as something more, or something else, we need to find out what it actually is. Three common answers to this question could be: 1) that digital technology is a combination of a sensor, an actuator, and a computer and that it be-

comes active through programs executed on the computer, or 2) that digital technology is a technology to treat, organize, and communicate information in a wide variety of ways, i.e., an information technology, or 3) that it is a device, which performs logical operations and mathematical calculations based on predetermined instructions, i.e., a Turing Machine. However, none of these definitions address the full potential of the material in a context of physical computing.

The reference to digital technology as *information* technology holds connotations of it being something that deals with representations, signs, and meanings. This understanding has led to the perception that computers are more than electrified machines. But digital technology does not deal with representations. Digital technology handles electrical charges according to an input from a sensory device (e.g. a keyboard). Every program has a physical manifestation when it enters the computer even if it before were representations on a piece of paper or in the programmers mind. Other labels commonly used when talking about digital technology are *software* and *hardware*, where software refers to programs that the computer executes, and hardware refers to the computer per se. This distinction has also contributed to the perception that computers contain representations. Some years back a mathematics student asked me when and how the binary numbers turned into electrical charges in the computer. A fair and probably not uncommon question because *software* holds the meaning of both the abstract representation of a program, whether in binaries or in a higher level programming language, and the program in its physical manifestation, whether stored or in execution. The point of this is that both software and hardware are physical and can be manipulated as such, and by accepting this we gain a view of the technology in which it is easier to accept its role in a physical environment.

While digital technology has a physical manifestation it does not explain what makes it a digital technology. It does, however, give us a point of departure to clarify this issue as the physical manifestation invites us to ask for the grounding structure of the phenomenon and more fundamentally *how* the technology exist. It is necessary to establish the boundaries of the digital technology, to determine where it begins and where it connects to other elements. In this process, we will identify what it comprises of, which again will impel us to transcend the physical and enter the temporal aspects of computation. How are the temporal and physical traits interrelated? To these and related questions am I currently seeking to formulate comprehensive answers. The present lack of space considered, I choose not provide partial ones here, but rather to jump ahead and expand on the notion of material composites.

MATERIAL COMPOSITES

A material used for design is a substance with certain properties, but the properties can change as the substance is manipulated. When materials such as aluminum, glass and plastic are used in design they have all been through a fabrication process in which properties have been refined or added. Aluminum, for instance, is refined from the naturally occurring bauxite to a state called pig-aluminum [2]. The properties of aluminum at this state are its corrosion resistance and its light weight. It is still a weak material only through alloys with other elements does it receive the strength it is commonly known for [2]. Thus, we can argue that aluminum is not one thing. That it is different depending on the refinement state as well as the type of alloy it is in. Material designers have developed aluminum alloys which can demonstrate properties suiting an immense variety of design situations. It is in this and similar insights from the world of material science that I find strong parallels to digital technology.

For the moment let us rely on the definition of digital technology in which we have a computer with an input and an output device. The computer comprises of the processor, storage, busses etc. but in itself it cannot be manipulated or programmed after it is constructed; its properties as a design material are only theoretical– it can calculate but for no apparent purpose. Hence, we need an input and an output device to interact with the computer. In their basic form, the I/O devices consist only of electrical charges that go in and out of the computer. Therefore, to have an effect they need to be part of something that humans can relate to. This is where the concept of an *alloy* or a *composite* has a great potential. It provides a way to understand what is necessary to bring out the properties of the digital technology as a design material, but the concept is also capable of sparking the designers imagination of all the possible composites which the technology can be part of.

In summary, I believe that through seeking inspiration from materials like aluminum and from the corresponding material sciences, it is possible to develop a design material from digital technology, which can inspire architects to weave it into the fabric of the buildings and urban environments they design.

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BIOGRAPHY

I am a Ph.D. student at the IT University of Copenhagen, affiliated with the Design of Organizational IT research group, which primarily conducts research within Computer Supported Cooperative Work, Participatory Design and Interaction Design. I have the privilege of being advised by Associate Professor Peter Carstensen, Design of Organizational IT research group, IT-University, Copenhagen and my co-advisor Associate Professor Johan Redström, presently a guest at Center for Design Research, Royal Academy of Fine Arts School of Architecture in Copenhagen.

I hold a BSc in computer science and psychology and an MSc in computer science both from the University of Copenhagen.

I expect to hand in my dissertation based on this project in September 2008.