A Material Focus - Exploring Properties of Computational Composites

Anna Vallgårda
IT University of Copenhagen
Rued Langgaards Vej 7
DK-2300 Copenhagen S
akav@itu.dk

Tomas Sokoler
IT University of Copenhagen
Rued Langgaards Vej 7
DK-2300 Copenhagen S
sokoler@itu.dk

CHI 2009, April 4 – 9, 2009, Boston, MA, USA
ACM 978-1-60558-246-7/09/04.

Abstract

In this paper we build on the notion of computational composites, which hold a material perspective on computational technology. We argue that a focus on the material aspects of the technology could be a fruitful approach to achieve new expressions and to gain a new view on the technology's role in design. We study two of the computer's material properties: *computed causality* and *connectability* and through developing two computational composites that utilize these properties we begin to explore their potential expressions.

Keywords

Computational Composites, Connectability, Computed Causality, Expressions, Heat, Materials

ACM Classification Keywords

H5.m. Information interfaces and presentation (HCI): Miscellaneous.

Introduction

In previous research [8] we laid out an account of computers as a material. We also argued that computers *per se* are inaccessible to the human sensory system because of their consistence of energy managed in sophisticated structures as two levels of voltage. Thus, computers will rely on other materials to come to expression.

In material science, two or more materials combined in an integrated manner make a *composite* material. They can enhance specific properties, introduce new combinations, or even create new ones. A *computational composite* is therefore, a composite material in which one part is capable of computing. Combined with materials holding properties such as tensile strength, opaqueness, thermal behavior, water or fire resistance, sonic abilities, strength in compression, deformability, and many others we can create an abundance of unique computational expressions.

Indeed, to develop computational composites we need to acquire knowledge about the computer's material qualities and potential – we need to study it both in theory and in practice. Studies, which would resemble those carried out within the discipline of material science. The studies of glass, for instance, lead to recognizing its impressive tensile strength when produced under the right circumstances [3]. A discovery later used for creating the popular composite material of glass fiber.

Contemplating the computer by itself it may seem to posses an endless amount of properties resulting from its extreme flexibility rooted in its binary design, Löwgren and Stolteman even called it a material without properties [6], but the organization of the computations does provide some constrains on the possibilities in and by themselves – what we can refer to as computational properties.

One example of a computational property already identified and studied to some extend is the temporality of computations articulated by Hallnäs and Redström [4] as *temporal form*. They argue that as computations are sequences of events in time, any meaningful incorporation of computational technology must exhibit temporal formation. Thus, for the materials connected to the computer to reflect the result of the computations they must be capable of changing between two or more states. Analogous to an old clock – if it has no hands to show the passing of time it has no value.

The remaining of this paper presents an argumentation for why such material focus is pertinent and deserves research attention and an argumentation for how it may pave the way for new expressions in design of artifacts and architecture comprising computational technology. Further, we study two computational properties *computed causality* and *connectability* both identified but not explored in our previous work [8]. The study entails a theoretical account for each property and a proposal of two computational composites meant as platforms for further material inquiry. The prototypes embody the delineated properties.

A Material Focus

Research areas such as ubiquitous and tangible computing are already aimed at finding alternative expressions to the all too familiar desktop setup with a keyboard, a monitor, and a mouse. And it lies within these endeavors to explore new combinations of computers and materials as means to create the new expressions (c.f., Ambient Room [5], Topobo [8], Dangling String [11]). This work, however, appears to be largely application-driven meaning that no general or systematic interest is placed in exploring the potential of the new material compositions. Our argument then is that an explicit interest in exploring the properties of the material compositions enables us to transcend the specifics of an application and thereby procure a viable approach to further expand the repertoire of computational expressions. We argue that a focus on computational composites in their own right – with the cross-disciplinary knowledge it acquires – will provide expressions otherwise not thought of. That this can be a way to avoid the tendency, which Anthony Dunne describes as "superimposing the familiar physical world on to [the] new electronic situation" [2, p. 17]

A parallel can be found in the rise of material science as a separate discipline where chemistry, physics, and engineering were combined in an effort to study materials as a whole [3]. The focus meant a substantial improvement in the knowledge concerning why materials behave the way they do – knowledge which in turn has led to the massive development of new materials that we have available today (c.f., [3, 4, 7]).

Another advantage of a material focus is the potential to develop a strategy that can bridge the gap between the sometime severe discrepancies of physical and temporal scales that interaction designers face when designing interfaces to the complex computational technology (c.f., [1, 9]). That developing an understanding of how computers can be integrated with other materials and how their common properties can be utilized provides a grip on how to handle these discrepancies.

A material focus would have two levels. One aimed at acquiring knowledge about computational properties and proposing new compositions of materials that would exploit those properties and together form a repertoire of computational composites. The other would be an integration of this repertoire or these ideas into the practice of design. Our current work can be seen as an effort to layout some ground for the first level. We are interested in finding material properties of computers and explore their potential expressions.

Two Material Properties of Computers

Computed Causality is a property grounded in computations' ability to make other parts of the composite to behave beyond our their otherwise normal behavior. *Connectability* is a property bound in computers' ability to form networks and thus to connect physically discrete entities.

These properties are in every respect different from traditional material properties; therefore, we need not only to establish a vocabulary to describe them but also a foundation on which they can be made accessible for experience. We therefore experiment with different combinations of materials and properties as means to render the computer's properties less abstract and more accessible for study. We present two conceptual designs of such experiments, as they are still work-in-progress.

Computed Causality
Property: Computed Causality
Basic expression: Cause-and-effects

As computational technology builds on a system of binary events, every input and every output must confine to this format. In the translation into the binary format, the manipulation by the algorithmic design, and the translation back into an analogous format lays a freedom to re-interpret and completely alter the cause of events in our material world. This element of freedom can be thought of as the core of digital computations, which put in a context of computational composites exhibits the behavior of what we will refer to as *computed causality*.

This property enables computational composites to express any imagined causality. In order for an expression to reflect the computed cause-and-effect the composite needs to turn the electrical energy, as produced by the computer, into forms of energy suitable for the other materials part of the composite (e.g., mechanical, thermal, chemical, or radiant energy). The ability to 'lead across' different forms of energy – to transduce – is what characterizes a transducer. Hence, for an expression to come alive in the computational composite a transducer or, to be more precise, a transducing mechanism needs to part of the composite.

To achieve a strong expression of computed causality we have chosen to turn our experience with a metal's thermal behavior up side down. We will build the composite from a cobber tube, a computer with a simple algorithm, Peltier elements, and probably temperature sensors (some inside the material and some outside isolated from the material) though we are still tinkering. The computed causality cause the computational composite to become colder the more exposed it gets to an external heat source and *vice versa*. Thus provoking our knowledge of thermal behavior in cobber (and other materials). For example, the more you rub the metal surface the colder it gets. This material sample would consequently behave opposite to what we, through experience, have learnt about metals' behavior.

In this case, the temperature sensors convey the temperature around the cobber tube to the computer which computes a corresponding decline in temperature and turns on the cooling or heating effect in the Peltier element respectively.

Figure 1 Illustration of how the material turns cold when rubbed by a hand an action that would normally warm it up.

Connectability
Property: Connectability
Basic expression: Connectedness

Connectability is the computer's ability to connect and communicate with other computers. This property is founded in computers' ability of handling protocols and thus through attached radio devices produce connections with other computers. It is arguable a second-degree property in the sense that it requires an additional device beyond the core computer, namely the radio, but the combination of the two is so common that in any practical sense it can be seen as a property of computers.

The expression of the property is that of connectedness – that something physically separated is capable of behaving as were it physically conjoined. This obviously holds a wide verity of expressions owing the specifics to the other materials of the composite, but basically the computational composite is a distributed material.

Figure 2 Connectedness demonstrated through a computational composite (the orange material) used for different purposes. When, for instance, the cup holds hot coffee the temperature of the back of the chair and stripe in the table will rise to ensure temperature equilibrium in the whole material.

To enable an immediate experience of connectedness in the computational composite we have chosen a traditional material behavior like thermodynamics to express the connection. When, for instance, one entity of the composite is cooled down all the parts will gradually adjust to achieve new temperature equilibrium. The composite will comprise: cobber, computers, radio technology, Peltier elements, and temperature sensors.

Discussion

What will be the outcome of this project? We will gain a better understanding of the computer as a material. We will not only know that computers need composite formations to come to expression and that they exhibit properties such as computed causality and connectability, but we will have a body of material examples to populate those theoretical explanations. Examples, which enable us to study computational composites through direct experience and not just as speculations and theoretical conjectures.

First, the fabrication of the material examples lends us insights to the practicalities around making computational composites; i.e., the particularities of making the right transducing mechanisms. Insights that sometimes deserve specific research attention in order to develop new mechanisms and to improve the flexibility of the material compositions; i.e., the scale of the material components, which in current prototypes can appear rather coarse and unsophisticated compared to traditional composite materials. The systematic tinkering with various compositions can help us better understand the various limitations and possibilities.

Second, the examples of computational composites form a foundation for experiencing the possible expressions of the computer’s properties. Our preliminary examples each focus on a single property but each property still has a myriad of different expressions just as combinations allow a complex scene of expressions. We are unlikely ever to form a complete picture but through populating the various aspects we will gradually gain a better understanding of the space of possibilities.

Third, the concepts and examples could form a way of understanding computers in a material context, which would inspire designers to engage new expressions in their designs. That even if the fabricated examples are not immediately applicable as design material, primarily because of their lack of material sophistication, they can still form an object of inspiration – a tool for thinking in new directions.

Temporal form, computed causality, and connectability are only the beginning of identifying and articulating computational properties. The ability to store values in a memory is, for example, another property worth studying. This project is part of a continuing dialectic exchange between elaboration of the theoretical framework and expansion the body of material examples.

Acknowledgements

We thank Olmo Ahlmann for assisting with illustrations.

References

[1] Djajadiningrat, T., Wensveen, S., Frens, J., & Overbeeke, K. Tangible products: redressing the balance between appearance and action, *Personal and Ubiquitous Computing*, 8 (2004), 294-309.

[2] Dunne, A. *Hertzian Tales - electronic products, aesthetic experience, and critical design* (2nd ed.) London, UK: MIT Press (2005).

[3] Gordon, J. E. *The New Science of Strong Materials - or why you don't fall through the floor* (second ed.). Princeton, UK: Princeton University Press (2006).

[4] Hallnäs, L. and Redström, J. *Interaction Design: Foundations, Experiments.* The Swedish School of Textiles University College of Borås and Interactive Institute, Borås, Sweden, 2006.

[5] Ishii, H. *et al*. AmbientROOM: Integrating Ambient Media with Architectural Space. Proc. CHI'98, Los Angeles, CA (1998).

[6] Löwgren, J. and Stolterman, E. *Design av informations-teknologi: Materialet utan egenskaper*. Studentlitteratur, Lund, Sweden, 1998.

[7] Manzini, E. *The Material of Invention -- Materials and Design*. Cambridge, MA: MIT Press (1989).

[8] Raffle, H. S., Parkes, A. J., & Ishii, H. Topobo: A Constructive Assembly System with Kinetic Memory. Proc. CHI'04, Vienna, Austria, (2004).

[9] Redström, J. Tangled Interaction: On the Expressiveness of Tangible User Interfaces. *Transactions on Computer-Human Interaction*, 15(4) (2008).

[10] Vallgårda, A. & Redström, J. Computational Composites, *Proc. CHI 2007*, San José, CA, USA (2007), 513-522.

[11] Weiser, M. & Brown, J. S. Designing Calm Technology, *Technical Report*, Xerox PARC (1995).