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Metadesign

Design for design: a path beyond mass customization

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Abstract Design exists in every aspect of human society. With the advent of mass customizations, the physical form of products, whether they exists physically or are merely information, has become malleable. However, the change is still only "skin-deep," and the underlying design and behaviors remain much the same. To change this behavior currently requires a great deal of capability. In this paper, we present the concept of a world of metadesign: a world where end users create not only form, but function. In this paper, we will highlight some of the aspects of computational malleability through discussion of several projects, as well as present a high level discussion of the issues guiding the act of design, and the benefits that may be garnered by allowing end users to customize the behavior of physical systems in lieu or in addition to being able to customize the form.

Keywords Metadesign · End-user Design · Behavioral Programming · Computationally Enabled Materials

1 Introduction

Design exists in every aspect of human society, and is perhaps the preeminent human characteristic. Design emerges from the nooks and crannies between disciplines, bridges the rough edges where these disciplines meet, and in the process creates artifacts that serve every basic human need. Physical design, the modification of raw materials in order to achieve some end or fulfill some need, has existed since time immemorial, and as such, materials have always been integral to design. As materials have evolved and advanced, design itself has changed in form or practice. More and more, design has abandoned its monolithic structure leading from concept to product, and has allowed the end user to affect the final entity. The ability of the end users to create various physical forms from existing data has now existed in the digital realm for some time, exemplified by digital "mash ups" and the recent Web 2.0 craze. More recently, the mass-customization of physical products has been gaining momentum. However, these changes remain, to some extend, only "skin deep," because they ignore an important aspect of design: behavior. In this paper, we suggest a combination of these roots with technologies and methods from the world of ubiquitous computing as a way of further extending this vision of design unbound.

2 Design and Designing

Before delving further, we should perhaps consider the differentiation between design and the act of design. Looking at definitions of the word design, we find definitions revolving around planning or conceiving, with an implicit nod to the idea of a goal. There is also an implicit idea of aesthetics and decoration that permeate the lay conceptualization of design, leading to the idea that anything that is designed in ornamented or striking. However, the act of design is quite different, and is perhaps best characterized by tradeoffs, made so much the worse by the lay definition of design, which may be best illustrated with a small anecdote. Let us consider the some criteria for a for relatively simplistic and unadorned city bus stop. This stop must be large, because people may have to wait in it, but it would be best if it didn't block the entire road. It must light and airy, but we must somehow accommodate advertisements. It must offer seating, but the seats shouldn't take up space that would better allow more to get shelter. The stop should offer protection from the elements, but shouldn't collect windblown dirt and debris. It should be difficult to vandalize, but it should be cheap too. At this point, we have a bus stop that is big and small, transparent and ad-covered, sheltering and open, offers seats and standing space alike, and is made of cheap materials that don't get damaged. Such are the poles to be reconciled by the magic of design.

While the example is of a public article that clearly has many users and their associated needs, the same algorithms are used to design things for private use, and this is where metadesign makes its case. Since many designs exist to serve only a single or a limited number of masters, there is room for much greater optimization of the object, environment, or interaction. Even in the case of a public object, interaction and

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behavioral change are not completely out of the question. Interestingly, behavioral change is more compatible with public objects than private ones compared to physical change, insofar as a public object's form is usually a tradeoff, while its functionality may be digital and thus more immediately malleable and shareable.

The metadesign manifesto was suggested by Fischer in the context of end user design [1], suggesting the need for users to be able to reclaim control over software systems, where the form and function are of course both highly and cost-effectively malleable. With ubiquitous computing systems and advanced materials that can support in-place computation, input, and output, however, we can now extend these ideas beyond purely digital media to the physical realm. Of course, if we consider the behavior of an object to be malleable, we must next consider the extent of this malleability. To state it in physical terms, we must consider not only whether our mass-customizable chair can have armrests and cushions, but whether it can be also a stool or not (and if so, what kind of stool). Rather than discussing this in abstract, we will present a set of projects progressing from allowing very minimal to almost complete end user modification of behavior.

3 ioMaterials Prototype: Handwriting

The first prototype we present very much borders mass customization, in that it allows limited change in behavior using physical changes. The handwriting prototype is a card which can mimic a simple thick paper card in physical size, but allows one-time recording of the handwriting (or drawing) patterns of the user, which can then be replayed as in an invisible hand were writing the message. It was created as an application use-case of ioMaterials, a generic name for materials that embed collocated input and output capabilities as well as computation and memory in a single substrate. This prototype precipitated from a reconsideration of animated and "active" cards available today, which contain active content, but leave the user to find a fit of pre-specified message to their own needs. An image of the prototype is shown in figure 1. We present this prototype, for the most part, to show that oftentimes the goal of designing for designability is as much an exercise in creating the substrate as it is creating the overall use-case.

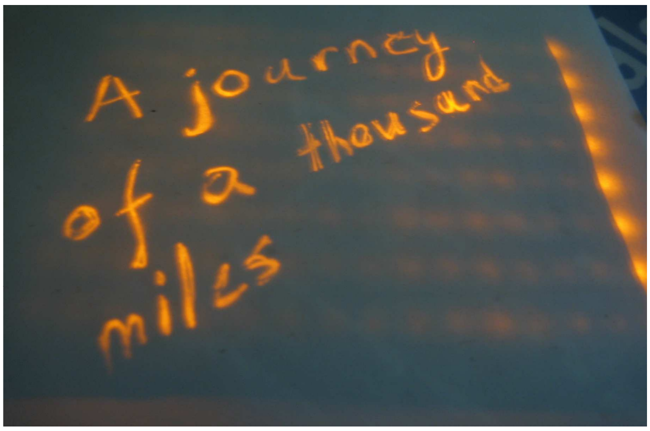

Fig 1 The ioMaterials handwriting prototype

While the idea of being able to send handwriting is hardly new, very rarely have we tried to embed this capability into material itself. Instead, we have created concepts involving boards, tablets, or LCD based interfaces [2]. Clearly, these approaches are out of reach for a product which is ultimately slated to be sold for a few US dollars. Instead, we chose focus on the quality of the card which it inherits from paper: its single-use nature. Using a transfer membrane as a mask, we allow, the user to etch a message into the mask, while using an extremely thin (0.5 mm thickness) paper-based sensing array, we record the position of the pen as a function of time. A co-positioned grid of LEDs can then shine through the sensing matrix and mask, replaying the sensed pattern and creating the appearance of real-time writing.

While the paper remains as single-use as ever, we allow users to communicate in a language that is not itself language by allowing them affective and expressive control over how the message is revealed. The user can write slowly, or quickly, or choose instead to draw, while imbuing the writing with their personal penmanship. While the control that this material allows over the behavior is quite simple, it does at the same time allow the user a much greater level of control over the *active* content of the card, rather than the passive (ie, textual) content. In some sense, we allow the user to affect how the text functions (ie, what it wishes to reflect) in addition to what the form of the text is.

4 Interactive Bus Stop

The interactive bus stop project, financed by the Parisian public transportation agency, RATP, was an attempt to extend individuality and interactivity to the public use realm [3]. The project was done in collaboration with the MIT Mobile Experience Lab. From the beginning, we wished to create not a monument of design or ingenuity, but rather a landmark for the space that the landmark occupied physically and socially. As such, this project is interesting in its interpretation of interactivity and changeability in a public setting, where the demands, as we highlighted in our introduction, are clearly varied and manifold.

As again, borrowing concepts from mass customization, the body of the bus stop itself was created using generative means that allow for each stop to be a unique variation on a theme. The inside of the bus stop is home to an interactive system that allows users to interact with functional information regarding the stop. On the other hand, the outside of the stop is a LED-based display that is designed to continue the metamorphosis of the bus stop after it is installed in its final location. The display surface was designed to cooperate with its surroundings rather than obliterate and dominate them in the way that the signs and displays of Times Square override their surroundings and context. The environment created by the displays of Times Square are unchanged by time of day or cast of sky, always producing sufficient brilliance to pump out information. We instead chose to create a display which was intentionally curved in order to accentuate the physical dimensionality of the

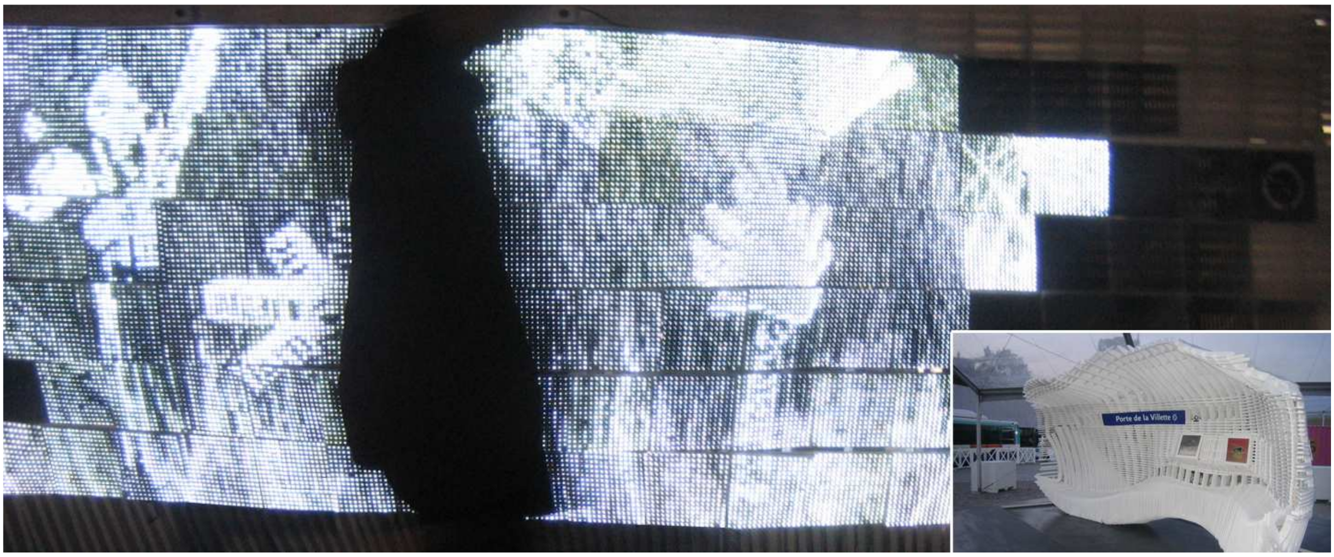

Fig 2 The back of the interactive bus stop (inset: front of bus stop)

underlying curvaceous structure. In addition, we treated with translucent silicone to form a composite that played with the light and shadows it gained from its surroundings, forming an image that faded seamlessly into daylight and just as easily merged its own into shadows.

While we did not have resources to implement all of the features we had originally imagined for this design, we created an urban digital garden which occupied the back surface, with its own kinds of plants, animals, and interactions. As users daily interact with this environment, either via the internal displays or by simply waiting or moving around the bus stop, the garden changes and grown as befitting its circumstances. We chose here to allow for some immediate forms of interaction, such as a large butterfly living in the garden that would occasionally come and “play” with humans standing nearby, but we recognized that too much immediacy was a detriment to the design, and allowed many of the features, such as the density of trees and the overall organization of the garden, to grow with time, allowing the final version to become unique to the location, but not without a modicum of control by the users. Additionally, the behavior of the active elements of the garden can also evolve over time with user intervention.

To some extent, the bus stop’s design explored the very limits of interactivity in public spaces, because by nature the stop is a transitional space, where users do not spend any significant time per episode. However, not all spaces are so limited by their nature, and the ability to inject user control and manipulation in something so public and affectively distant as the bus stop indicates that many of the spaces that we likewise now consider to be too public to personalize are in fact open to further inspection. While we will never be able to agree on the light or temperature level in a room, we must also remember that design for design is still a matter of tradeoffs, and while completely practical or crude physical changes may not possible with multiple individuals, not is the possibility of change completely impractical in appropriately gentle hands.

5 subTextile: A Behavior Definition Language

Lastly, we present a representative from the far end of the spectrum of metadesign: a language and associated hardware systems designed from its inception to support end user design and development [4]. The premise of subTextile is relatively simple: it is a very simple visual programming language for computationally enabled materials (such as the ioMaterials effort) that is designed to program interactive behavior for small physical effect units that can do simple tasks, such as control grids of LEDs, take input from sensors, etc. It achieves its extreme simplicity and *apparent speed* (as opposed to temporal speed) by reducing the number of things a user must learn, while providing a very deep scaffolding system that hides complexity without sacrificing control. The language, still under development, currently consists of only eight commands, and can nonetheless express most interactive programs.

The language achieves high *apparent speed* by using a completely event driven model, where things happen in response to external stimuli, rather than the C language approach of polling. Of course, internally polling and interrupt-driven activity does take place. However, this optimized layer is used to drive an event layer which ensures that within reasonable resource bounds (ie, microcontroller speed), the reaction to an input happens “instantaneously.” Additionally, complete features are broken out into external modules, which allow the master controller to delegate time-intensive processing to peripheral units while freeing the user from the physical bounds of the master control unit. These features differentiate the system from both graphical languages such as Scratch [5] and textual languages such as Wiring [6], which tend to abide by the same rules as C, as well as physical platform such as the Arduino [7], which employ a physical interfaces rather than virtualized controls of peripherals as a basis for hardware control.

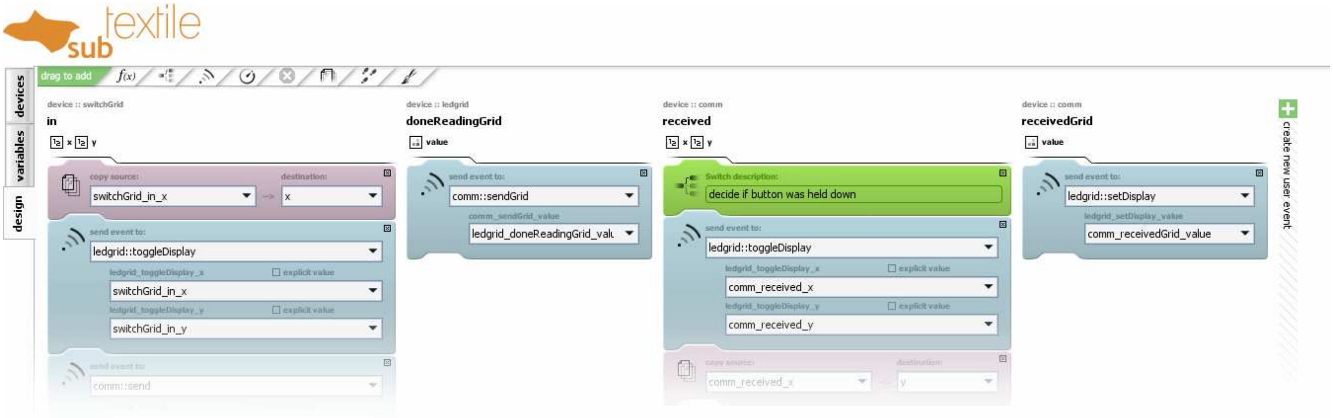

Fig 3 The subTextile development environment

SubTextile offers an extreme offshoot of independence from the will of the designer in that it is designed to "package" skills into chunks that can be easily understood, documented, and manipulated. With regards to behaviors, it offers an opportunity to accomplish the effective opposite of mass customization, in that the form of the component devices that make up the final composite may be determined by the designer, while their behavior and interplay is determined by the end user. However, the level of control exposed by subTextile goes far beyond what is suitable for the lay user, and it is thus not suitable for general consumption. But for those with expertise in other areas, subTextile offers a means of using skills much as we use them today when we choose to use some complex or engineered material or semiconductor device. SubTextile makes this knowledge itself commodity with regards to working with computationally enabled materials.

6 Conclusions

We have presented here a set of prototypes that suggest different levels of metadesign of behaviors, with the suggestion that perhaps behavior may well be the next step in user generation and design. We have the benefit of standing at a juncture in history where one such transition has taken place within our lifetimes: the World Wide Web has transitioned from a norm of static and controlled content to a norm of user generated content bound by user-created agglomerations. However, even in the digital realm, the actual behavior of content, and at a low level, the underlying algorithmic manipulation of content, remains outside the reach of the everyday user. This is a natural product of the control of the underlying data and processing capabilities, which remain outside the reach of the end user.

However, in the physical world, the constraints are reversed. Objects and materials gain greater computational and responsive capabilities continuously, while the physical fabrication and change of materials remains a more difficult proposition. We are thus surrounded by devices whose behaviors we have an opportunity to affect, but whose forms must remain constant. Through the examples in this work, we present the concept of metadesign as an answer to the opportunities and challenges thus created, and attempt to show that regardless of restrictions imposed by environment or resources, it is possible to create artifacts with inherent behaviors that retain their malleability for the end user.

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