Fusing Computation into Mega-Affordance Objects

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Abstract
In this paper, I present the concept of "Mega-Affordance Objects" (MAOs). An MAO is a common object with a primitive form factor that exhibits multiple affordances and can perform numerous improvised functions in addition to its original one. In order to broaden the reach of Tangible User Interfaces (TUIs) and create compelling everyday applications, I propose applying computational power to Mega-Affordance Objects that are highly adaptable and frequently used. This approach will leverage the capabilities of smart materials and contribute to the principles of Organic User Interface (OUI) design.

figure 1. Duct tape, an exemplary Mega-Affordance Object.

Keywords
Tangible User Interface, Mega-Affordance Objects, smart materials, Organic User Interface

ACM Classification Keywords
H.5.2 Information interfaces and presentation: User Interfaces

Introduction
The lifecycle of successful technologies typically involves a progression from incubation to early adoption to widespread usage [1]. While understanding this adoption curve is often regarded as a marketing challenge, I believe it can also drive creativity and an intellectual understanding of an emerging research area. In the case of Tangible User Interfaces, which as a field is arguably in the incubation or early adoption stage, asking the question "how do I design a tangible interface that will be used by millions?" forces a different perspective on the choice of user interaction techniques, underlying data flow, material and construction methods.

Over the past ten years, numerous TUI projects have been developed in the areas of augmented surfaces, ambient information displays and graspable objects that embody digital information [2]. While a few products including Nintendo Wii and Apple iPhone have successfully introduced individual features seen in TUI projects, the vision of integrating user input and system output in a transparent manner has yet to be deployed in a large scale.

Design Principles for Everyday Tangible Interfaces
With the goal of developing a TUI concept that will be enjoyed by a million users, I have identified following design principles:

1) Embed computation within the tangible objects
Many TUI concepts require large equipments and the computational intelligence driving the system exists external to the object users interact with. For example, I/O Bulb and Luminous Room use a spatially-separated-camera-and-projector setup, and the underlying software was run by a hidden desktop computer [3]. Similarly, I/O Brush requires a computer hidden behind a projected surface. The object—the brush—only has image capturing capability, and the rest of the computation is done by the hidden computer box [4].

When the computational power is external to the object, the prototype becomes bulky, which greatly limits its portability. Embedding the computational power within the objects themselves simplifies the use and makes TUIs more portable and manageable, thus more appropriate for a large-scale deployment.

2) Accommodate common and multiple use scenarios
TUIs serve a specific function for certain domain experts (urban planning, landscape design), entertainment (digital music performance), or creative activities for children (painting) [4][5][6].

While this approach has been effective in contextualizing the value of TUIs, the affinity for specialized functions becomes a barrier when it comes to seeking an acceptance from a large audience. The barrier increases further with the large physical dimensions and complex operations of the prototypes.

One approach to overcome this issue is to bring computation to tangible objects that serve a large number of functions. For instance, if the TUI took the form of a duct tape or binder clips, it would naturally serve larger user base than Sandscape could.

Digital Duct Tape

Duct and packing tapes are one of the most versatile products frequently used by a vast majority of population. In addition to its original function of attaching two separate pieces together, tapes are used as an informational and expressive canvas, and even as a construction and sculpting material.

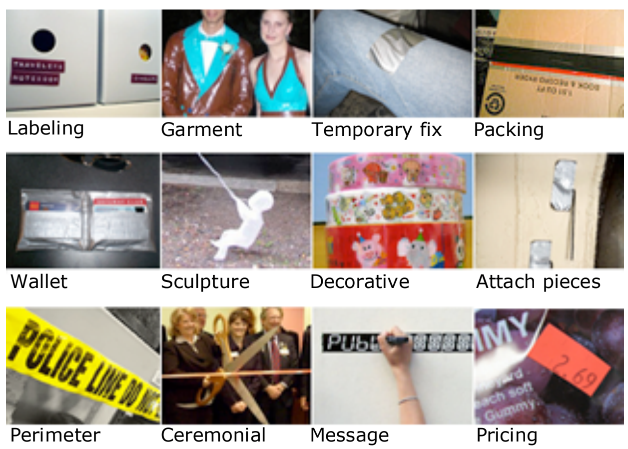

figure 2. Versatile usages of tapes. [7]

Due to their extensive affordances for actions including cutting, peeling, stretching, stacking, rolling, lumping, aligning, and writing upon, duct tapes are clearly differentiated from single-function objects such as a backpack, a picture frame or a mouse, or from convergence electronics like the Apple iPhone.

Applying even a simple digital ability to duct tapes can yield interesting results. For instance, if you could assign a textual or graphical content to a duct tape piece before you dispense them, any surface could transform to ambient or on-object displays instantly. You could put labels on your belongings that update over time; displayed content may duplicate if you tear and split the tape piece into two. Duct tape's inherent affordances create unique opportunities to map underlying digital data flow to the object's properties and a variety of user actions in both creative and practical manners.

Mega-Affordance Objects

Identifying the unique opportunity duct tape brings to introduce TUIs for extensive everyday use led me to look for other examples of objects with unusually broad range of affordances and investigate their common characteristics. I have tentatively named this class of objects "Mega-Affordance Objects (MAOs)." Current definition of an MAO is a "ubiquitous object with a primitive form factor that exhibits multiple affordances and can perform numerous improvised functions in addition to its original one."

Figure 3 outlines the elements that consist an MAO, along with a few examples I have identified.

	MATERIAL PROPERTIES	FORM FACTOR	USER ACTIONS		RESULTANT USAGES
	Simple	**Primitive, modular**	**Various**		**Versatile**
DUCT TAPE 	Adhesive Flexible Two-sided Textured Waterproof	Cylinder Strip	Cut Tear Peel Stretch Fold	Roll Stack Lump Attach Write on	Attach Label Set perimeters Sculpt Visual guide
CARTON BOX 	Sturdy Thick Opaque Layered	Flat or cube Large surfaces Muti-sided Folds flat	Fold Unfold Stack Cut Put objects inside	Nest Write on Roll Crease	Contain objects Hide objects Transport objects Stepping platform
NEWSPAPER 	Thin Frail Easily soaked Flammable	Flat Large surfaces Multiple pages	Lump Fold Tear Roll Tile	Read Write on Burn Stack Clip	Wrap bowls Protect surfaces Start fire Stuff in shoes Blanket when cold

figure 3. Elements and examples of Mega-Affordance Objects.

Conclusion: Computational MAOs

In this paper I have characterized a particularly useful and ubiquitous class of physical objects as Mega-Affordance Objects (MAOs). I believe that computationally-enabled MAO's are a strong potential contribution to the fields of Tangible and Organic User Interfaces. Practically, they can reach a much broader range of users than existing TUI's, and lend themselves to newly emergent usages through improvisation. Intellectually, MAOs are an important class of objects to understand, both for their broad range of existing uses in the physical world and for their potentially augmented uses in the physical/digital hybrid of TUI's. Finally, they offer a broad, yet specific lens with which to view, understand, and inform the emerging field of Organic User Interfaces.

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