Kinesthetic media

touch, toys & interactive materials

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Abstract

The Tangible Media Group at the MIT Media Lab has done a series of investigations into new multi-modal interactive toys and interfaces that utilize gesture and the sense of touch to improve interpersonal communication, education, and access to digital information. Our vision is to improve people's access to computers by creating computational media that take advantage of existing skills people have developed through working with physical objects [Ishii and Ullmer 1997]. Kinesthetic media are computational toys and materials that use movement to support communication and learning through physical interaction. This article will survey the design and motivations for kinesthetic media through two example projects, Topobo and Super Cilia Skin: an Interactive Membrane.

1 Introduction

Topobo is a 3D constructive assembly system with kinetic memory, the ability to record and playback physical motion (figure 1) [Raffle and Parkes 2004]. By snapping together a combination of Passive (static) and Active (motorized) components, people can quickly assemble dynamic biomorphic forms like animals and skeletons with Topobo, animate those forms by pushing, pulling, and twisting them, and observe the system repeatedly play back those motions. For example, a moose can be constructed and then taught to gesture and walk by twisting its body and legs. The moose will then repeat those movements and walk repeatedly. The same way people can learn about static structures like buildings by playing with blocks, they can learn about dynamic behaviors like animal locomotion by playing with Topobo.

Super Cilia Skin (or "SCS") is an interactive membrane that allows two people to communicate over a distance by manipulating the orientations of an array of yarn-like actuators (figure 2) [Raffle et al. 2003]. When a device in one place is touched, the gesture is reflected in the paired device, transforming the touch into a tactile and gestural image. SCS metaphorically interprets biological "skin" as an actuated, sensory interface between a computer and its environment. We imagine actuated fur could replace the plush fur used in children's toys like a teddy bear, and become an interface for dynamic behaviors. Compared to the sirens and flashing lights that fill today's toy stores, an actuated textile may facilitate a more organic, subtle and creature-like interface. It may be these subtle, organic qualities of textural materials that help children form the personal, emotional connections that make objects an important part of development.

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Figure 1: Using Topobo, two eighth grade girls invented this moose and taught it to walk by cooperatively twisting its body and legs.

2 Related Work: Touch and Toys

A potential value of tangible information interfaces is their connection to our bodies, our senses of touch, and kinesthesia. Recent studies in children's education have argued that children have a separate bodily intelligence that includes masterful coordination of their body movements and the ability to manipulate objects in a skilled manner [Gardner 1983].

Frederick Froebel's Kindergarten provides an early and important instance of specialized objects in education. Froebel distilled his world view into a number of kindergarten "gifts," physical objects that children used in daily lessons to learn about common forms and processes found in nature. The kindergarten gifts had a deep influence on 20th c. art. For instance, Frank Lloyd Wright credited kindergarten as the basis for his aesthetic vocabulary, and many of his architectural forms are similar to artifacts from the kindergarten classroom. Similarly, all of the founder of the Bauhaus either attended or taught kindergarten [Brosterman 1997]. Such evidence shows the strong influence educational objects can have on children's aesthetic development.

Physical materials can also help children develop skills manipulating abstract concepts. Educational manipulatives are toys that are specially designed to help children with this. For example, "Cuisinaire rods" allow children to explore the abstract concepts of arithmetic by manipulating concrete, physical blocks of different lengths. By arranging blocks to create series of equal length, children can discover that 1+3=2+2.

While the use of physical materials in education has a rich history in the last century, the introduction of computers to classrooms

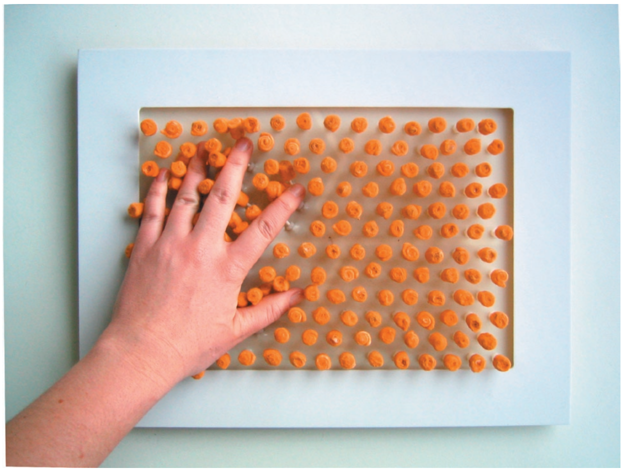

Figure 2: Super Cilia Skin gives a display "senses," allowing a visual material to become a tangible interface to computational information.

has focused on screen-based activities. In an effort to develop an alternative to screen-based computer activities, Resnick presented "Digital Manipulatives," that embedded electronics into familiar children's toys. He argued that interactive, programmable materials can take advantage of the privileged role of physical, tactile material in children's education while using computers to make certain complex ideas like feedback and emergence more salient to them [Resnick et al. 1998].

One outcome of this work is the development of computer interfaces that are programmed through physical interaction, and some of these projects have explored the idea that material can have memory.

3 Approach

In the design of Super Cilia Skin we built upon existing tangible interface research and used the concept of scale to expand this work in new ways. In the history of tangible interfaces, materials are rather rare. From its conception, Super Cilia Skin was intended to be a scalable, multi-modal material that could retain some of the tactile and material qualities of cloth while enabling new interactions and interpretations through modern technology. Our design studies focus on communication and affect, both of which are important themes in tools for learning.

Topobo was designed to retain the best qualities of existing manipulative materials while giving the material a new identity, an identity that can both reveal new patterns and processes to children, and that allows children to creatively express patterns and processes that can not be expressed with existing materials. To achieve this goal, we established design principles that focused on play, multimodal learning, scalability (both pedagogical and technical) and that technology should add to the good qualities of building toys (e.g. still be engaging with the power turned off) [Raffle and Parkes 2004].

The development of kinesthetic media has been guided more by aesthetic decisions chosen for their appeal to us as artists and designers, than by engineering decisions chosen to create an optimized performance. This approach contextualizes a type of research that focuses on the history and chronology of craft. The craft tradition embodies a history of people who have a knowledge of how things are made and how to make things with which people intimately interact. This was an important foundation for our development of both Topobo and SCS because computer technology has traditionally been developed either as engineering with a clear solution, or as art whose value can not be easily measured.

4 Motivation

Prior to my research at MIT, I worked as an artist and designer of educational toys. My art focused on the emotional motivations and liminal relationships between people and technology. With artist Michael Grey, I helped design and develop the ZOOB® toy system (figure 4), which is based on the joints of the human body and the body's dynamic relationships to macro systems like the cosmos and micro systems like DNA.

ZOOB provided a conceptual foundation for a building system like Topobo: prior to ZOOB and Topobo, there were only two variations of manipulative modeling: stereotonic building, or stacking based on the brick and development of the city, and tectonic building based on engineering from the industrial revolution to Buckminster Fuller [Grey 2005]. Topobo introduces dynamic modeling based on how the body works (from crystal geometry to skeletons) and how networks and information behavior relate to the animation and dynamics of physical systems.

I joined the Tangible Media Group (TMG) at MIT Media lab in 2002 to further explore the relationship of computer technology on design and learning. While TMG's work on interpersonal communication and interactive surfaces has guided Super Cilia Skin, the toy "curlybot" provided a new insight into the ideas of memory and reflection. With curlybot, children can use to record and playback movement on a flat surface, exploring ideas related to narrative and geometry [Frei et al. 2000].

Toys can be a sort of Trojan Horse for new ideas, playfully introducing concepts, relationships and metaphors to children, a group who is hungry for new ideas. As Resnick and others have argued, the subtle integration of computer technology into familiar children's toys can allow children to experiment with ideas like feedback, emergence and systems behaviors that have previously

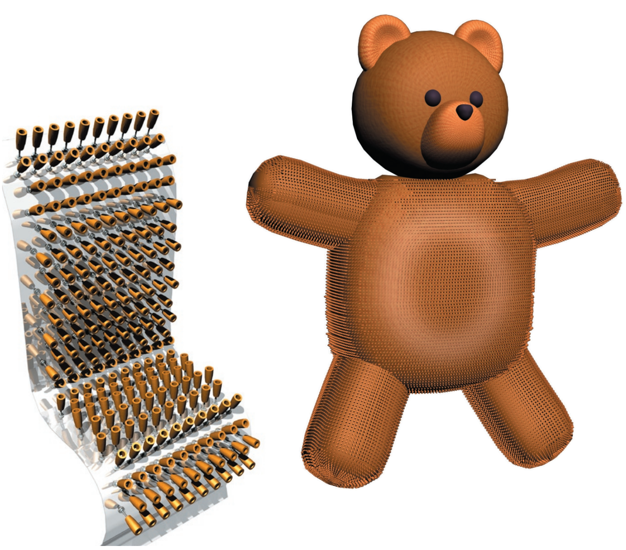

Figure 3: Super Cilia Skin conceptual rendering. SCS could someday be wrapped around children's toys to engage emotions and support learning.

Figure 4: ZOOB is a building toy based on the dynamics of skeletons and DNA.

been considered too complex for children [Resnick et al. 1998]. Research in learning, design and human-computer interaction provides a foundation for this current work in kinesthetic media [Brosterman 1997; Papert 1980; Piaget 1976, Weiser 1991].

5 Looking Ahead

Our work to develop kinesthetic media is based on the ideas that computers will change the way children construct meaning and knowledge about the world. Children will do this learning as much in the classroom as they will outside of it, so technology should support playful, informal learning that can happen as much in the living room as it can in the classroom. Our work in gestural learning is intended to help children form affective and intellectually engaging experiences; experiences with kinesthetic media could provide an intuitive foundation to understand complex behavior and relationships that exist in the world,

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Figure 5: K-3rd graders experiment with Topobo.