Spime Builder: A Tangible Interface for Designing Hyperlinked Objects

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ABSTRACT

Ubiquitous computing is fostering an explosion of physical artifacts that are coupled to digital information – so-called *Spimes*. We introduce a tangible workbench that allows for the placement of hyperlinks within physical models to couple physical artifacts with located interactive digital media. A computer vision system allows users to model three-dimensional objects and environments in real-time using physical materials and to place hyperlinks in specific areas using laser pointer gestures. We present a working system for real-time physical/digital exhibit design, and propose the means for expanding the system to assist Design for the Environment strategies in product design.

Author Keywords

Spime, Tangible User Interface, Virtual Environments, Gestural Interfaces, Product Design, Interior Design, Exhibit Design, Design for the Environment.

ACM Classification Keywords

H5.m. Information interfaces and presentation (e.g., HCI): Tangible User Interfaces.

INTRODUCTION

We are increasingly surrounded by *Spimes*, objects "that can link to and swiftly reveal most everything about [themselves]"[15]. Global supply chains have created a need to track material and energy usage to ensure quality and to promote Design for the Environment [6]. Concern over toxic ingredients in everything from toys to food has prompted efforts to verify supply chains. Eco-labels on products and packaging are growing more sophisticated to inform consumers and to efficiently direct materials through waste management[18].

Ubiquitous computing techniques including RFID and distributed sensors are making it possible for every object to bear a unique identifier that links it to digital tracking information. Massive databases and more recently on-line social networks are emerging to document the history and specifications of individual products [19, 22]. Some innovative mobile systems have been developed so that consumers can access provenance information while shopping [8, 3].

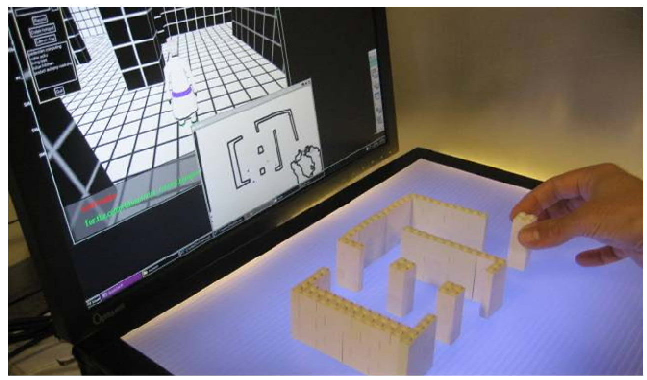

Figure 1. Spime Builder is used to lay out wall elements in the physical and the digital model simultaneously.

Hyperlinked objects are opening up a world of possibilities for alternate models of design, manufacturing and ownership. Physical environments that are linked to digital representations – such as museum exhibits mirrored on-line – are available to much larger audiences. Toys that are linked to unique avatars in virtual worlds have fostered new value propositions [21]. Automobiles that are linked to on-line reservation websites and opened through RFID keys can be shared, making them more useful *and* less wasteful [23]. Hyperlinked products can promote new market models where value lies in sustained service independent of the need to consume more energy and materials. Imagine if every material in a laptop was designed to be extracted and re-used at the end of its life. Life-cycle accountability relies on information that accompanies each object over its entire life so that the greatest value can be extracted with the least material cost.

Spimes are digital *and* physical objects – but the practice of designing a physical artifact is usually separate from interaction design. There is a need for new tools that make it possible for designers to simultaneously conceive of the physical *and* digital natures of hyperlinked products. The *Spime Builder* is a Tangible User Interface that seeks to couple the physical modeling process with techniques to produce an interactive digital model containing hyperlinks to on-line information (see Fig. 1). It contributes a simple technique for defining hyperlinked areas in physical models. The Spime Builder is a prototype for a next-generation design tool to merge physical and digital design into a single practice in preparation for a future where interaction and connectedness will become central to the value of most physical products.

RELATED WORK

Physical modeling is fundamental to concept development and presentation in many physical design professions, including architecture, interior, fashion and product design. Tactile models allow direct manipulation and provide direct feedback while promoting improvisation and collaboration in diverse groups. However there is a growing need to interconnect physical designs with interaction and with digital information, something nearly impossible to do in physical models. Some architects are resorting to computer game design software to place interactive elements in their physical designs [2].

Tangible User Interfaces preserve many benefits of physical interaction while incorporating interactive features from digital design tools. Tabletop interaction using symbolic bricks and augmented reality afford teamwork and allow complex modeling to take place on a shared physical frame of reference [4,13]. Several interfaces have been proposed to allow architects and designers a way for their physical models to be immediately translated into three-dimensional virtual environments [1,5]. Groups of users can see the space from a first-person perspective while modeling physical material on an augmented workbench. While many are limited to orthogonal arrangements of blocks, more fluid designs are possible with real-time 3D scanning [10].

Tangible Interfaces can enable designers to place interactive elements within a physical artifact, retaining many of the benefits of physical modeling [7]. In one tabletop interface, users position camera tokens in the model to see the space from that perspective [20]. But token-based annotation is limited to point inputs. More fluid and expressive areas can be annotated using a pen or, in one case, a light pen [9,14].

Using an intuitive tool can facilitate the merging of digital and physical design space. In one project, a paintbrush has been retrofitted with a digital camera, enabling users to 'paint' with samples of video captured by daubing the real world [12]. In another, an augmented stamp shaped like a microphone allows children to record sounds into their drawings [11].

The Spime Builder is built on a Tangible workbench for physical modeling with coincident, real-time scanning and generation of a virtual model. A novel and inexpensive technique is introduced where a laser pointer – a common tool in design presentations – is used to place links to digital information in the model.

DESIGN

While digital design tools have become extremely powerful and essential to design practice, the affordances of working with physical materials – especially when designing physical objects – cannot be replaced by screen-based systems. Based on this assumption, we designed the Spime Builder to seamlessly accompany physical prototyping with intuitive functionality to achieve the essential characteristic of a spime: to link the object with digital information. We designed the system to demonstrate the benefit of designing these environments and serve as a conceptual platform for future development of spime design tools.

The Spime Builder was designed to be easily integrated into design practice, both in size and shape and to make use of equipment common to many design studios. The most important affordances of physical models are that they are persistent, three-dimensional representations (enabling collaboration) that can include a wide variety of physical media (encouraging improvisation). The Spime Builder was designed as a workbench with three open sides where people could stand and interact around a shared frame of reference. Common materials are used, including a light box, plastic blocks and a laser pointer. A physical model can be built as usual, with the added benefit that regions within the model can be encoded with hyperlinks to on-line information. All of the digital information is shown on an adjacent display so as not to interfere with the physical model.

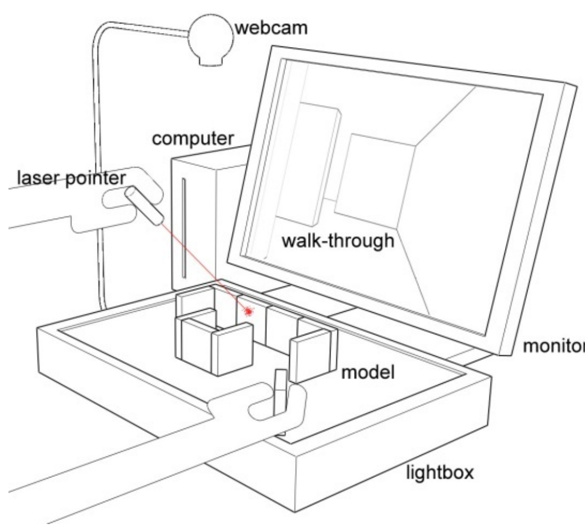

Figure 2. Spime Builder is used to lay out wall elements in the physical and the digital model simultaneously.

The Spime Builder is made with components that already exist in many design studios. It consists of a webcam, a light-box and a computer (1.5Ghz PC) with an LCD monitor. The physical model is built atop the light box, where solid materials obscure the light and an overhead camera can easily discern the resulting silhouette (see Fig. 2). A Python program uses the OpenCV library to detect the silhouette contours and output them in real time as two-dimensional coordinates. The OpenGL library is used to extrude these silhouettes into the walls of a virtual environment. A third-person avatar-based view is rendered in real-time using the Soya 3D game engine [17]. In order to detect the laser pointer, a second OpenCV process returns the location of a bright red dot. When a designer enters a web address into a dialog box on-screen and presses a 'record' button, the Python program observes the location of the red dot over three seconds and returns the boundaries of the movement. These are translated into a 'hot spot' in the 3D model; when the avatar wanders into the area a browser window points to the pre-defined website.

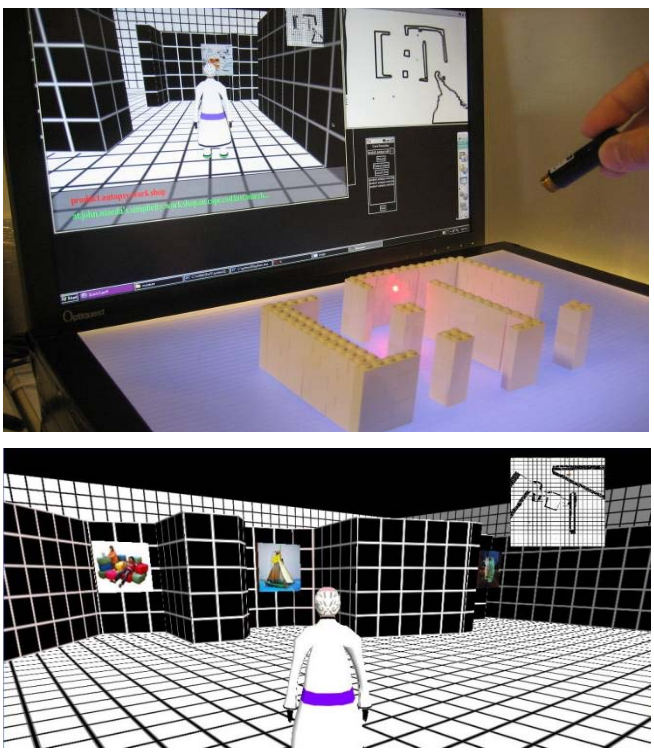

Figure 3. Placing a painting in the gallery with a laser pointer (above); visiting the on-line exhibit (below).

Use Scenario: Exhibit Design

The current version of the Spime Builder was built to support the simultaneous design of a painting gallery and an on-line exhibit. In common exhibit design practice, a scale model is built complete with miniaturized artwork for design and presentation purposes. Similarly, users can lay out the gallery walls on the Spime Builder by placing blocks on a workbench. In real time, a three-dimensional interior model is rendered on an adjacent screen; this model can be navigated by a separate joystick or keyboard. An avatar walks through the space, providing a third-person perspective (See Fig. 3).

Designers place paintings in the gallery using the laser pointer technique discussed in the previous section. When the avatar approaches the painting in the digital model, a browser window opens with information related to the art work. This could be useful to on-line gallery visitors who are interested in learning more about a specific piece. The same hyperlink could be placed in the physical gallery in the form of an optical bar code or an RFID tag; these could be used by visitors with interactive gallery guides to open related web pages.

Use Scenario: Product design

In a future version, the Spime Builder will be modified to add hyperlinks to product design mockups to help enact life-cycle design strategies. Life–Cycle Design refers to the emerging practice of conceiving products in a way that considers all of the materials and processes involved over the course of their existence [6]. It is commonly used to design environmentally benign products whose materials can be effectively re-used at the end of life; it is a way to transition from a business strategy centered on planned obsolescence to subscription- and service-based alternatives. Bruce Sterling describes his vision of a Spime as an object with links to:

"the full list of Spime ingredients (basically the object's material and energy flows), its unique ID code … various handy recipes for post-purchase customization, a public site for interaction and live views of the production chain and bluebook value… At the end of its lifespan the Spime is … entirely disassembled and folded back into the manufacturing stream. [16]"

Figure 4. Product designers could place meta-data in specific parts of an object to assist in maintenance (simulation).

The design of Spimes relies on a life-cycle approach where a digital model follows an object to inform users and to account for materials and energy over multiple generations. Using a next-generation Spime Builder, a designer could link a particular object or part of an object to any type of digital content. This could empower a tinkerer to repair a product; it could offer information about available upgrades and customization; and as technology evolves the links could provide new strategies for re-use and recycling. In a simulation, a modified version of our Spime Builder is used to define regions on a product and associate information from the web about that part. Users could retrieve the data by touching that part of the object on a workbench with overhead projector; they could likewise contribute their own significance to the object to imbue it with greater value (see Fig. 4).

DISCUSSION

Our Spime Builder is an early conceptual prototype aimed at fostering an added layer of authorship in the design process, one which heightens consciousness of the life-cycle impact of design decisions. Our design is based on two fundamental assumptions: 1) the belief that physical modeling will continue to be a cornerstone of design practice and 2) given many of the privacy concerns that self-tracking objects could engender, our system is entirely based on a *direct control* metaphor where any data associated with products is consciously entered by a designer or an owner, not automatically mined using ubiquitous sensing.

The Spime Builder only addresses a basic function of hyperlinked objects (a genre that includes Spimes, Hybrid Objects, Computational Artifacts in the literature) – the need to connect physical matter with digital information. Other than placing these links within the physical domain, the Spime Builder does not address many of the other features of physical-digital objects, such as the design of actuators, communication networks and other interactive elements common to computational artifacts.

In the future, we will develop the second scenario of the Spime Builder so that information can be encoded in physical objects, retrieved and edited using widely available technology. To this end, new optical tags need to be developed that uniquely identify every object and provide orientation information so that augmented reality information can accurately overlay the object. In addition, a web-based infrastructure needs to be developed so that located hyperlinks in physical objects can be easily tied to a database. Finally, mobile applications will have to be built to make the information available to anyone with a camera phone.

CONCLUSION

The Spime Builder is an on-going project that seeks to anticipate the need for designers to embed interaction in products and environments. We are working with designers to find the best strategies for hyperlinked artifacts. Preliminary discussions with curators and product designers reveal that each project benefits from a different type of digital ‘shadow.’ We hope to develop more specialized Spime building applications to expand the expressive power of designers, shifting the value away from material and energy consumption toward sustainable, long-term relationships with consumers.

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