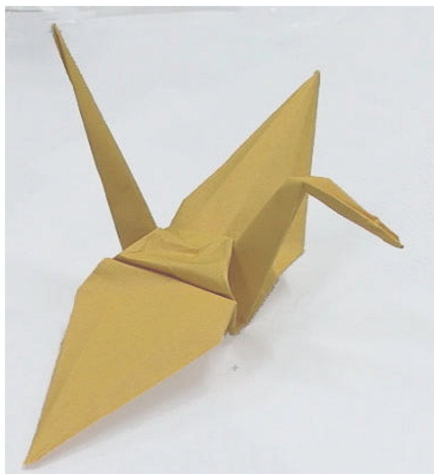
SIGGRAPH 2001 Emerging Technologies Proposal

Origami Desk



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Proposal Summary

This proposal details the design of Origami Desk, an interactive installation where participants are guided through the creation of various origami structures. The workspace will provide instructions demonstrating sequences of folds using sound, pictures and video, and choreograph the participant's actions with projected graphics. Participants can step through the instructions at their own pace by touching various "hot spots" on the projected interface. The progress through the instructions is monitored by the workspace in order to provide participants with feedback if their folding should go awry. The installation utilizes several ground-breaking interaction technologies, including electric field-sensing arrays, and low-cost radio-frequency identification tags. This exhibit aims to illustrate how real world graphics, interaction design and innovative sensing technologies can be pragmatically integrated to create interactive environments that help users perform process-driven tasks.

Introduction

The progress of computer technology into everyday consumer appliances makes possible new applications that interact with people in their day-to-day lives, helping them complete commonplace tasks and acquire new skills. The Origami Desk pulls together several on-going research projects at the MIT Media Lab to illustrate how the judicious combination of new technologies might enable computers to guide users and to actively respond to their actions.

The Origami Desk is an interactive installation where users learn to fold paper into beautiful shapes. Origami Desk improves on the inscrutable origami diagrams we all know and love by showing videos that demonstrate what the hands should do, projecting lines onto the paper showing where the folds should be, and monitoring the folds of the paper to give the budding origami artist feedback if their folding should go awry. In addition, the exhibit will utilize architecture and music that complements the spare elegance of the folded structures the users will create.

Background

CounterActive

The Origami Desk is the Zen reincarnation of CounterActive, an interactive kitchen counter that teaches people to cook. Because the CounterActive interface is projected onto the kitchen counter, users can work on top of the recipe, flipping through the instructions and pictures of the recipe without getting any pages dirty. CounterActive uses Dynamic HTML to provide movies, music and help on demand, bringing the liveliness and adventure of cooking shows out of the living room and into the kitchen where people actually cook. As mentioned in the accompanying video, the underlying principle that drives the design of CounterActive is that users are *not* cooking with computers. They are cooking on the kitchen counter with their kitchen implements, just as they've always done; it is just that the counter and implements are more helpful.

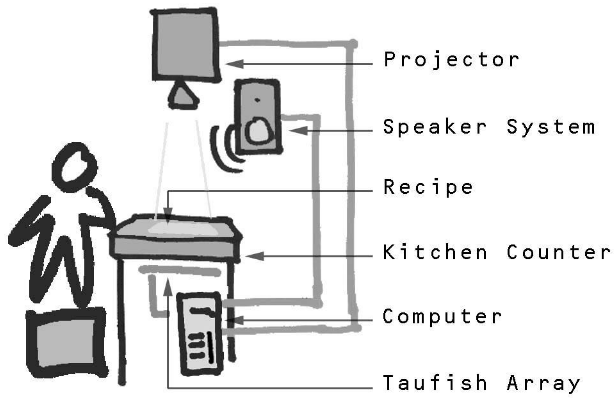

Figure 1: Diagram of the CounterActive system

Interactive Table

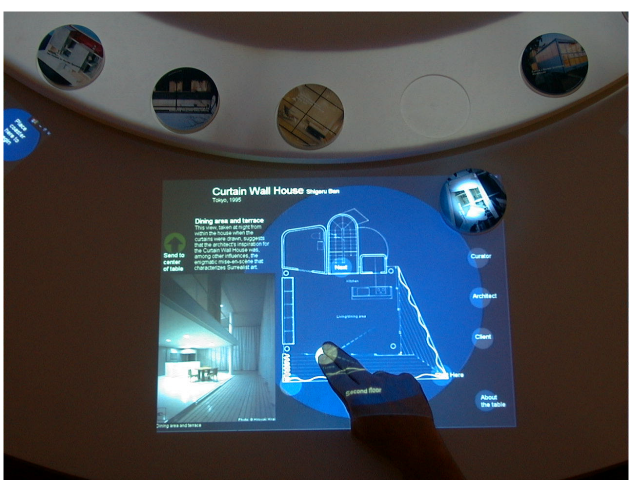

Figure 2: Interactive Table place setting

CounterActive itself is a reincarnation of "interactive furniture" created by the Media Lab's Physics and Media group for the Un-Private House exhibit at the Museum of Modern Art in New York. This exhibit featured a large eight-foot diameter Interactive Table with eight place settings arranged round a lazy Susan. The lazy Susan held 26 coasters, each representing an architectural work. At each place setting, a user can place one of the coasters over a spotlit circle to activate an interactive segment on the architectural work associated with that coaster. The Interactive Table is itself the reincarnation of John Underkoffler's Urp, but utilized wholly different technology to track the objects and hand gestures that allow the user to interact with the digital media.

Technology

The Origami Desk demonstrates the latest in a rapidly emerging line of sensing technologies that enable computers to break free from the CRT-keyboard-mouse interaction paradigm. These technologies allow interactions to transpire in the user's space, eliminating the need for metaphoric mapping between the digital world and our physical one.

Electric Field Sensing

Electric field sensing (EFS) lets computers to detect where a user's hands are. Coupled with a visual interface, this sensor allows the dynamic mapping of digital buttons and handles. This technology is an improvement over touchscreens and their ilk because it does not require direct contact. Hence, the interactive surface can be one that is rugged, impervious to dirt or spills and more conducive to active work in general. It also has advantages over computer vision because it requires far less computing power to parse the sensor data.

Figure 3: The tauFish array

The Interactive Table and CounterActive both employed tauFish arrays for electric field sensing. A tauFish array is composed of thirty tauFish modules, each attached to four electrodes. The tauFish detect capacitive loading on each electrode by charging it up to a known voltage and measuring the time it takes to discharge the electric field below a hystereic threshold The measured capacitance for each of the 120 electrodes is communicated as a 24-bit value via a multi-drop serial bus to a central microcontroller at a rate of about 10Hz. The entire array board outputs data at 115Kb/s. The recipient computer then takes the measurement to create a forward model of induced charge on the electrodes. Used in conjunction with *a priori* knowledge of the target activation regions, or "hot spots," this forward model allows the computer to know when the user has touched a relevant spot on the interactive surface.

Electromagnetic Tagging

Tagging gives digital identities to physical objects. Electromagnetic tags make it possible for computers to recognize objects and materials, to track them in time and space and to associate information with them. For the interaction designer, the primary advantage that electromagnetic tags have over visual tags, such as barcodes or color spots, is that they do not require line of sight. This means that an object can be tracked during course of a user's normal actions, without the cumbersome "scanning" step typical of systems utilizing computer vision.

The predecessors to the Origami Desk utilize a variety of tagging technologies. The Interactive Table used simple, low-cost inductor-capacitor resonators of printed copper in the coasters to create physical icons that were recognized by tag readers mounted under the interactive surface. The tag reader operated in the 5MHz to 40 MHz frequency range, reading the resonant frequency of each tag to identify the coasters from one another. These tags are considered to be “passive” for they have no active electronics or data processing. Their behavior is dictated purely by their capacitive and inductive characteristics, so they do not broadcast dynamic information.

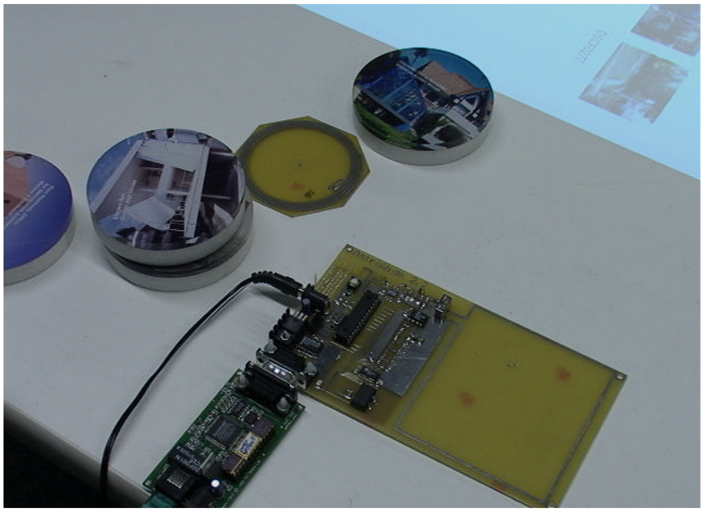

Figure 4: The tag reader and coaster tags

In contrast, the CounterActive project is integrating “active tags” into standard kitchen implements to give user’s feedback about their actions. Rather than using tags that only resonate in view of the tag reader, CounterActive tags that have microprocessors that can “read” broadcast information (such as physical location) and sense other environmental data (such as acceleration or pressure) before wirelessly transmitting information to a central receiver. This will allow the CounterActive counter to track ingredients over the work space, and to create tagged tangible tools that cross the digital divide, such as rubber spatulas that can detect whether the user is mixing instead of folding, and lets that user know the difference.

The Origami Desk breaks new ground in the tagging domain by using inexpensive passive tags in an active domain, by reading the resonant frequencies of copper coils printed onto origami paper. Because the resonant frequency of the passive tags is dependant upon the geometry of the planar electromagnetic resonator, the folding of the origami paper will change the resonant frequency read by the tag reader under the interactive surface. These readings will in turn allow the computer to infer whether the origami artist has properly completed the folding step, allowing the possibility for correction or clarification. The power of this technology is that the messages sent to the system are incidental, not explicit, and hence will not draw the user’s focus away from the task at hand.

Viability

The technologies behind the Origami Desk are currently at various stages of development. The tauFish array technology is fully functional, and the hardware and software has been implemented and tested. However, the tagging element of the Origami Desk is still under development. Though the production of the tagged origami paper and the tag reading technology required by the Origami Desk is well understood, they have yet to be made or tested. We also need to experiment to correlate a variety of printed geometry for different folded structures. Though we feel confident that this aspect of the project is wholly viable, the Origami Desk installation is designed so that it can perform successfully without it.

Design

Just as important as the underlying field sensing or tag reading of Origami Desk is the design of the overall system that motivates and directs the user's interaction with these technologies. Origami Desk inherits many of the principles developed in the design and testing of the CounterActive.

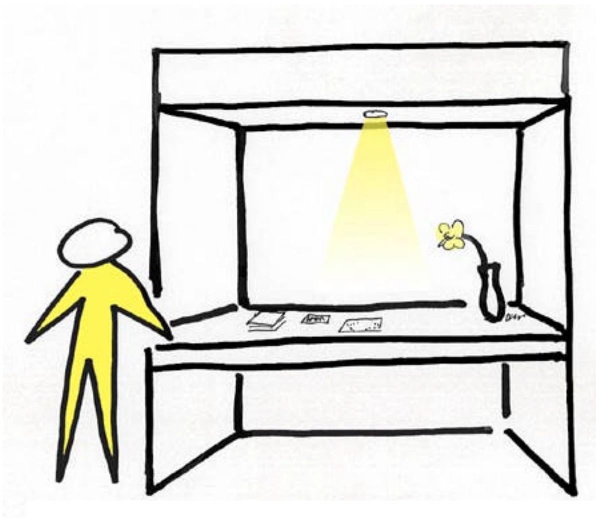

Figure 5: Concept drawing for Origami Desk

The environment of Origami Desk helps to engage the user and to put them in the frame of mind to enjoy a good session of paper folding. The physical structure supporting the desk not only supports the multimedia projector, but also acts as a screen to block out outside distractions and stray light. The installation uses background music to soothe the participant, and creates an environment that is relaxing and fun.

Origami Desk's visual interface draws on the principles derived from the design and testing of CounterActive. The projected workspace is delineated into three types of spaces: *interaction areas*, where the user would interact with the system's written options to issue explicit commands to the computer, *display areas*, where the system would present pictures and videos to help the user see what to do, and *work areas*, where the user would place raw materials or work on folding paper. The carefully considered layout of these spaces helps to choreograph the user's actions, and prevents actions in the workspace from inadvertently triggering commands.

The user's actions are directed in several ways. First, written and verbal instructions indicate to the user what they are doing in general. Then, videos demonstrating each set of folds help the user see the moves they need to make, and present an image of the paper at each stage. Projected shapes and diagrams on the workspace aid the users in understanding exactly where to put folds and what the outline of the shape should be when done. Finally, the tagged origami paper is read to give the feedback about whether the resultant geometry of the paper is correct. These instructions are be designed so as not to detract from the central task of learning origami by making the structures.

Impact and Implications

Though it is deceptively simple, Origami Desk is a powerful embodiment of how real-world graphics, interaction design and innovative sensing technologies can be pragmatically integrated to create interactive environments centered around the human user. These technologies and design techniques can be utilized anywhere where people are actively engaged in a task—in assembly lines, at an electronics workbench, at home in the kitchen. This demonstration also illustrates how to blur of the boundary between the digital and the physical world through the use of projected graphics, tagged objects and sensing of people.

The Team

The Origami Desk is a good example of what happens when a diverse set of people fall under the spell of the same crazy idea.

Leonardo Bonanni (amerigo@mit.edu) is a Master's of Architecture student at MIT and has spent the last year designing prototypes for MIT's House of the Future Project (House_n). He wants to design objects and spaces that unequivocally improve our quality of life through embedded computing. Leonardo will be designing and building the physical structure of Origami Desk.

Richard Fletcher (fletcher@media.mit.edu) is a PhD candidate at the MIT Media Lab. His thesis research centers on the development of folded copper structures for low-cost electromagnetic tagging. His research will be integral to the folded origami tags on this project.

Rebecca Hurwitz , **Tilke Judd**, and **Jenn Yoon** ({beckyh, tjudd, jennyoon}@media.mit.edu) are undergraduate researchers at the MIT Media Lab. Their work with Wendy Ju on the design and production of the CounterActive cookbook has made them adept at many things, including digital video production and editing, dynamic HTML programming, user testing and food photography. They will be working on the content production for the Origami Desk project.

Wendy Ju (wendyju@media.mit.edu) is a Masters student at the MIT Media Lab. She leads the CounterActive project and is interested in the interaction design of environments. She conceived the idea for Origami Desk while working on various ideas for the next generation of CounterActive. She will be the lead designer and coordinator for this effort.

E. Rehmi Post (rehmi@media.mit.edu) is a Ph.D. candidate at the MIT Media Laboratory in the Physics and Media group For the "Unprivate House" exhibition, Post integrated his work on gesture-sensitive computer interfaces into a giant interactive table installation. His interest in digital electrometry and the inverse electrostatic problem enabled production of the field sensing arrays used in the Origami Desk project.

Matthew Reynolds (matt@media.mit.edu) is a PhD candidate at the MIT Media Lab. Matt is radio-frequency system engineering who works in the area of radio positioning systems. Matt will investigate the use of active tags for the Origami Desk.

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