I/O Brush: Beyond Static Collages

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Abstract

I/O Brush is our ongoing effort to empower people to create new expressions and meanings by painting with attributes of everyday objects and movements in their physical world. Using examples from our case studies with kindergarteners and artists, we discuss I/O Brush's most distinguishing features, its dynamic ink and history functions, and how they enable people to invent new expressions and meaning making with objects in their physical environment.

Keywords

Drawing, Children, Storytelling, Interaction Design, Tangible User Interfaces, Usability Research, User Experience, User Interface Design, User Research

ACM Classification Keywords

H.5.1 [Information Interfaces and Presentation]: Multimedia Information Systems—artificial, augmented, and virtual realities
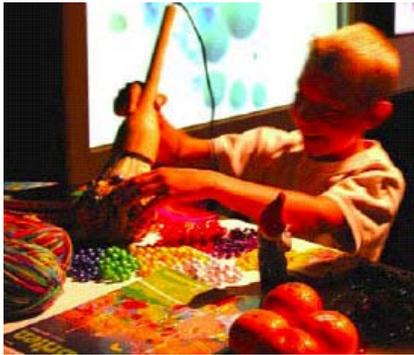
Introduction

"We continually personalize and humanize the given environment as a way of both adapting to it and creating order and significance."

— Csikszentmihalyi [1]

We live in a physical environment and create a cultural environment within it. Each of us, in varying degrees,

creates "a little world of our own" with objects. In this little world we create with objects, we express ourselves, and learn about ourselves and the world around us.

The project described in this paper is about empowering people to create new expressions and meanings by harvesting attributes of everyday objects and movements in their physical world. I/O Brush: the World as a Palette is our ongoing effort to support such creations and expressions with people's everyday objects.

I/O Brush: The World as a Palette
I/O Brush [3] is a physical paintbrush equipped with a small video camera with lights and touch sensors embedded inside. Instead of picking up paint, the I/O Brush can pick up colors, textures, and movements of a brushed surface. On the canvas, artists can draw with the special "ink" they just picked up from their immediate environment. For example, by picking up a texture from her pet dog's fur, movements of her own blinking eye, color from her favorite shirt, and by combining these elements into a unique drawing, the artist can not only create a thoroughly personalized piece, but also breathe a new kind of life into the canvas.

In this paper, we discuss distinguishing features of the I/O Brush system crucial to user's creative experience. Specifically, we describe how I/O Brush supports the invention of new expressions with the following two important features: 1) I/O brush allows the artist to both capture moving objects, and then draw with such "dynamic ink" from her environment, and 2) I/O brush automatically and continuously records and preserves

I/O Brush allows people to take attributes from objects in the physical world and immediately paint with them.

the process of creation (the "history") in both the audio and visual domain. With examples drawn from our case studies with children and an adult artist, we will look at both the process and the product of people's creation with I/O Brush, and discuss how the I/O Brush system supports the kind of explorations that lead people to invent new expressions with objects around them.

The design evolution of the I/O Brush system
This project has been an interdisciplinary effort in HCI research, mechanical and electrical engineering, software development, and artistic expression. Over the course of the project's life time so far, I/O Brush has been adopted in multitude of quite diverse settings.

In spring of 2005, a corner of a kindergarten classroom served as the home for an I/O Brush system. For 5 weeks, I/O Brush was the kindergartener's daily free-style activity. During that time, we studied intensively the tool's potential to support creative learning and conceptual change, i.e., how working with I/O Brush changed the way children looked at their environment.

One version of the I/O Brush system has become a long-term interactive art exhibit at the Ars Electronica Center in Linz, Austria (August 2004 - August 2006). The opportunity to take I/O Brush to the Art world, and to work with artists at the museum, inspired us not only to refine I/O Brush as an interactive art piece, but also to develop its most advanced and intricate features, such as the palette, dynamic ink, and the history capturing function.

Finally, as a research prototype, I/O Brush's main home has been at the Tangible Media Group's lab space at the MIT Media Lab, where live demonstrations are

given to the sponsors of the Lab on a daily basis. The system, however, has not been commercialized yet.

Dynamic ink: Beyond static collages

One of the unique qualities of I/O Brush is its capability to allow the artist to create dynamic expressions that extend into both the spatial and temporal dimension. This is made even more intriguing for the artist since she is able to apply those techniques during the capture process, as well as during the paint process.
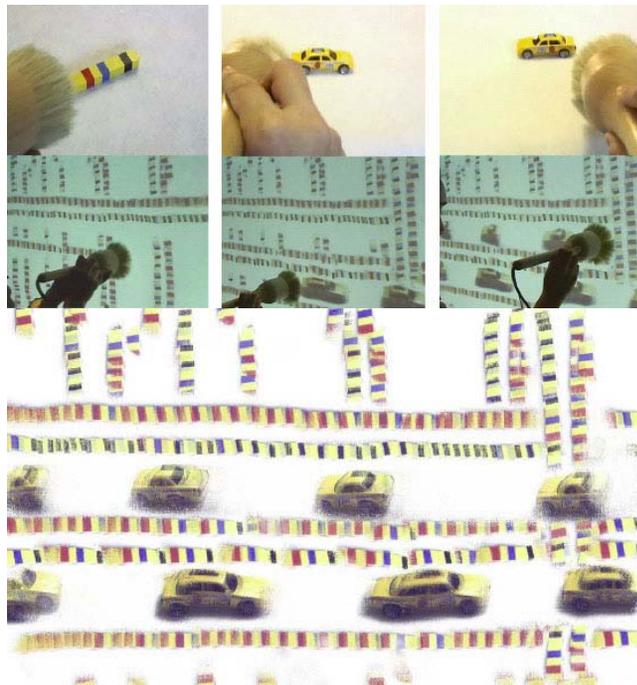
Figure 1. "NY" created with dynamic ink.

I/O Brush has two main modes of drawing: Static and Dynamic. In the Static mode, I/O Brush captures a
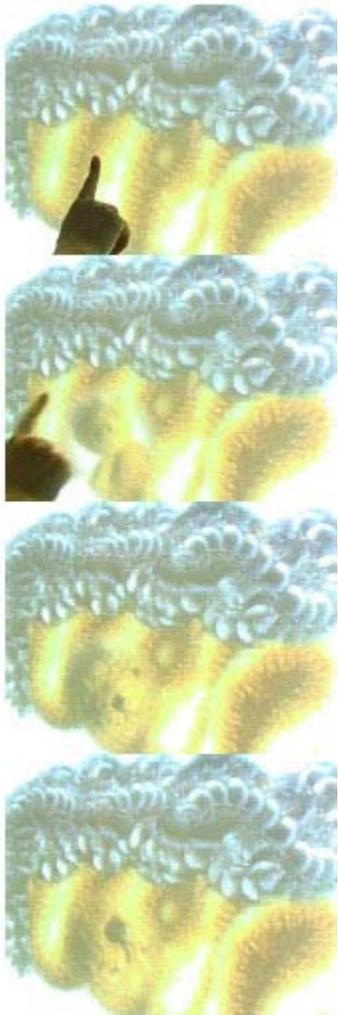
snapshot of the brushed surface, which consists of one frame. The Dynamic mode grabs a sequence of consecutive frames of the brushed surface and lets the artist draw with the movement she captured.

There are several ways to create "animated ink" on the canvas. An artist can create dynamic ink by either capturing a moving object (such as a blinking eye), or by capturing a static object and applying a relative motion to the brush during the paint process. For example, an artist can create a dancing smiley face by twisting the brush while capturing a static smiley face.

More complex animations can be created by combining the dynamic capturing and dynamic painting processes. For example, when an artist brushes over a static text in dynamic ink mode, and then brushes over the canvas with this ink using an equivalent speed but opposite direction, the artist can make the brushed over text scroll on the canvas.

An artist can also capture an already dynamic object, such as a butterfly with flapping wings. When this object is captured with relative movement, the resulting ink on the canvas is an animated butterfly, including flapping wings, that wanders around the canvas.

Since I/O Brush allows an artist to both capture and draw using the same physical device—exactly like painting with a real paintbrush—the interaction is completely grounded in the artist's physical hand movement. This physicality invites the artist to experiment with the above described complex expressions easily. By combining dynamic capturing techniques, and varying the direction of the capturing

motion and the brush strokes, the artist can create a variety of dynamic expressions.

History functions

Another unique quality of I/O Brush is its ability to document and preserve the origin of all ink. This feature was inspired by our observations of interactions exhibition visitors had with I/O Brush at our long term exhibit at the Ars Electronica Center. As they saw previous visitors' works of art with I/O Brush, some people showed interest in investigating where the previous visitors had gathered their colors from.

To document the process of where the ink originates from, both the video camera and the microphone inside the brush are active and recording continuously even before the artist picks up a new ink. Later, when the artist initiates a new stroke on the canvas, the last 5 seconds before the artist brushed over the surface are stored, and linked to this specific stroke on the canvas. These 5-second "documentary" mini movies (both the audio and video portions) are activated and played back on the canvas when the specific brushstrokes are touched later on. The surface of the canvas is touch sensitive due to a touch screen overlay on the plasma screen canvas. When the audience touches a certain part of the portrait, a 'pop up' video appears on the canvas at the touched part and plays back the movie that was automatically recorded during the artist's creation to document the "heritage" of the ink. In other words, each brush stroke on the canvas has a sort of 'hyperlink,' which takes the audience onto a journey to where this specific element has originated.
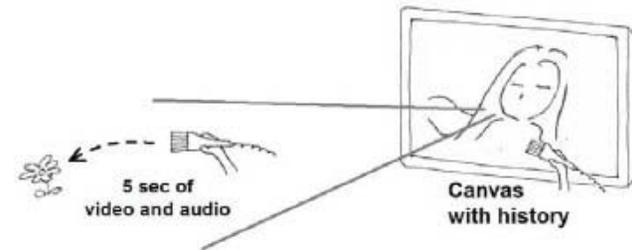
Touching the canvas reveals where the colors came from.

Figure 2. Capturing where the color came from.

Therefore, the canvas serves as a space where the artist builds her portrait, but it also serves as a space where the artist and audience can peek into the history of the portrait, revealing short "making of" clips of each and every stroke.

Children's work with I/O Brush

We now turn our discussion to how the dynamic ink and history function supported children's expressions and play. Ten children (aged 5 to 6) played with I/O Brush as one of their "choice time" activities in their kindergarten classroom, about 2 or 3 times a week, for 5 weeks.

Turning personal objects into a dynamic ink
Children grasped the idea of "animated ink" quickly as they tried out the "movie mode" to capture non-static targets such as their gasping mouths and blinking eyes. However, combining relative motion in creating dynamic ink seemed too advanced a concept for most kindergarteners. Nevertheless, children did explore the dynamic expressions they were able to create with the dynamic ink function. For example, one child discovered that brushing over her pink sweater in movie capture mode, and then drawing a squiggly line

with this dynamic pink ink would result in a dancing pink squiggly line. She brought her friend in front of the canvas and repeated her drawing as she explained to her friend, "Look, I'm making a pink worm!" She transformed the pink ink extracted from her pink sweater into a dynamic moving object. The physical brush made it easier for her to recreate what she had created previously.

Space for recording play and performance
Children also seemed to understand how the brush recorded their creation process. However, instead of using the history function to preserve and document the origin of the ink, some children used the function as a tool to act out their play scenes and put them on canvas for their ongoing play and reflection. For example, some children discovered that singing a song while capturing ink would result in an ink that they can use to paint. But more importantly, later touching the painted surface on the canvas would play back their singing, and this playback could be shared with their friends and teacher.

Figure 3. A child discovers I/O Brush captures her singing.

In summary, some children focused on the visual aspects of their projects with I/O Brush, carefully working with the tool's ability to capture colors,

textures, and movements. Yet some children focused on the tool's ability to capture an audio-visual history of the creation process. These individual performance styles of kindergarteners, i.e., different approaches to expressing and meaning making [2] were enabled by the dynamic ink and history functions of I/O Brush.

Case studies with an artist
In addition to the long-term Ars Electronica Center exhibition, we have also conducted a case study with a water color artist. The I/O Brush system was brought to the artist's home, following the artist's request to paint in a more personal and intimate environment than our research lab setting.

A new process of creation
In preparation for her work with I/O Brush, the artist spent more than one hour retrieving and arranging objects on her kitchen table. Her kitchen table became an intricate physical palette of personal objects. A collection of old keys, a basket full of seashells, a plate full of sliced apples neatly arranged, a collection of stones and gems, etc. She arranged her objects in a way so that different themes, patterns, and colors seemed to emerge in anticipation even before she started to paint. It appears that a new process of painting was brought out when the artist spent time preparing the materials she needed for her portrait.

Weaving personal messages into the canvas
One of the paintings the artist created was called, "Family Women." For this piece, she used personal family photos as the source of her ink. Photos symbolized her favorite female family members, including her two daughters and her grandmother who meant dearly to her.

Close-up view reveals that the portrait is made of colorful candies and their packages. "Hershey Kisses" (top) and "Red gum" and its package (bottom).

She touched these photos with the brush and used the palette to make sure she was capturing the faces of her favorite women. During this process, she recorded personal messages. "This is my nana Folly, my father's mother, Jenny." [as she picks up a photo of young Jenny] "Jenny is a sweet sweet sweet lady. You can see the sweetness in her face." [as she paints] Therefore, personal messages were embedded in each brush stroke.
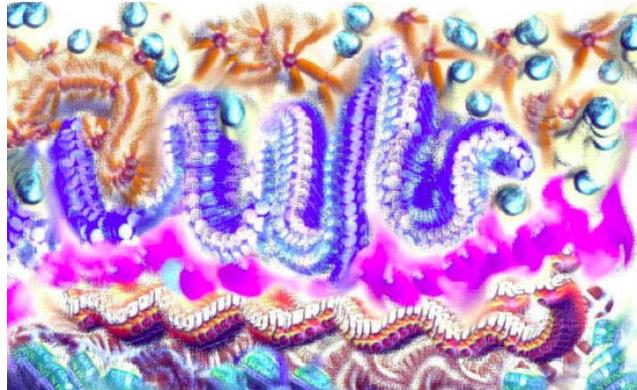
Figure 4. "100 Carrot Sweets"

In most settings, and especially in museums, audiences are often discouraged (or even explicitly prohibited) from touching paintings. In contrast, the portraits made with the I/O Brush system invite the audience to take a closer look, to touch the canvas, and hopefully to reveal the (hidden) messages that may be embedded in the strokes.

Discussion and conclusion
For children, I/O Brush's ability to capture dynamic ink ("movie mode") and preserving the creation process of

ink ("history") became a means to support their individual expressions and work styles. For artists, the system provides a canvas with multiple layers where they may construct and embed complex messages into the portrait. The artist can leave an audio-visual message, via the history function, for each of the "personal inks" she created. The I/O Brush system provides a channel where artists can embed personal communications in the visual materials that are used to create their art pieces. The artist's messages behind each stroke, and the juxtaposition of the ink and its meaning, adds additional depth to the portrait.

The combination of capturing and drawing with both temporal and spatial attributes enables the invention of new artistic expressions. In the future, we hope to see galleries of artwork full of new and exciting artistic compositions, enabled by I/O Brush in the hands of thousands of artists.

References
[1] Csikszentmihalyi, M. & Rochberg-Halton, E. (1981). The meaning of things: domestic symbols and the self. New York: Cambridge University Press, 1981.

[2] Gardner, H. (1982). Art, mind, and brain: a cognitive approach to creativity. New York: Basic Books, 1982.

[3] Ryokai, K., Marti, S., and Ishii, H. I/O Brush: Drawing with Everyday Objects as Ink. In the Proceedings of CHI 2004, ACM Press (2004) 303-310.

Interactivity Supplement
CHI 2007, San Jose

The Interactivity Supplement shows how conference attendees will interact with your work at CHI 2007. It is intended to give as rich a picture of your project and presentation requirements as possible. **This document is for the purposes of review only and will not be published.**

To explain how your project works, you can for example provide a short usage scenario, a storyboard sketch, screenshots, illustrations, and/or photos.

The Supplement also includes the various technical requirements such as preferred setting, space, power, networking, lighting, acoustical, and other special equipment.

It is important to remember that the reviewers of Interactivity submissions can only make decisions based on the knowledge contained in this document, the extended abstract, and the optional video. Therefore, it is through the supplement that you have the opportunity to informally describe how you envision CHI 2007 attendees interacting with your piece.

The full call for CHI 2007 Interactivity can be found at:
www.chi2007.org

If you have any questions, please contact the Interactivity co-chairs Lars Erik Holmquist and Tom Igoe, at:
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DESCRIPTION

Title: I/O Brush: Beyond Static Collages

Project Description (100 words max):

I/O Brush is a new drawing tool to explore colors, textures, and movements found in everyday materials by "picking up" and drawing with them. I/O Brush looks like a regular physical paintbrush but has a small video camera with lights and touch sensors embedded inside. Outside of the drawing canvas, the brush can pick up color, texture, and movement of a brushed surface. On the canvas, artists can draw with the special "ink" they just picked up from their immediate environment.

PRESENTATION HISTORY

I/O Brush has been presented in various phases of development at the following venues:

- Ars Electronica Center Linz, Austria (August 2004 - August 2006)
- BETT Educational Technology Show London, UK (January 12-15, 2005)
- Wired Magazine's NextFest 2004 San Francisco, USA (May 13-16, 2004)
- TED Conference 2004 Monterey, CA, USA (February 25, 2004)

Two CHI paper presentations were made about I/O Brush, one long paper in 2004 and one design paper in 2005. I/O Brush has not been presented in live action at CHI.

We propose to have our most recently developed version of I/O Brush at CHI 2007 Interactivity for the following two reasons:

1) Since our last presentation at CHI 2005, there has been a significant development effort resulting in new features. Specifically, "dynamic ink" and the "history" function have not yet been demonstrated live in a large scale venue like CHI. The general public may have seen some of the I/O Brush's functions in our videos available on the web. However, for these dynamic features, a live demonstration would be an ideal form to get the "feel" of how the dynamic quality of the tool actually works.

2) Experience shows that the I/O Brush project evokes interest from a variety of communities, including design, art, technology, education, and human-computer interaction. The CHI audiences' multidisciplinary background creates an ideal forum for multidisciplinary discussions on design, engineering, and interactions based on the live interactions.

ENVISIONED INTERACTION

We envision that our I/O Brush exhibit consists of three parts:

1. Main interactive canvas with I/O Brush (left)
2. Example art made with I/O Brush (to demonstrate the "History" function) (right)
3. Interactive video kiosk, showing clips of previous art pieces (middle)
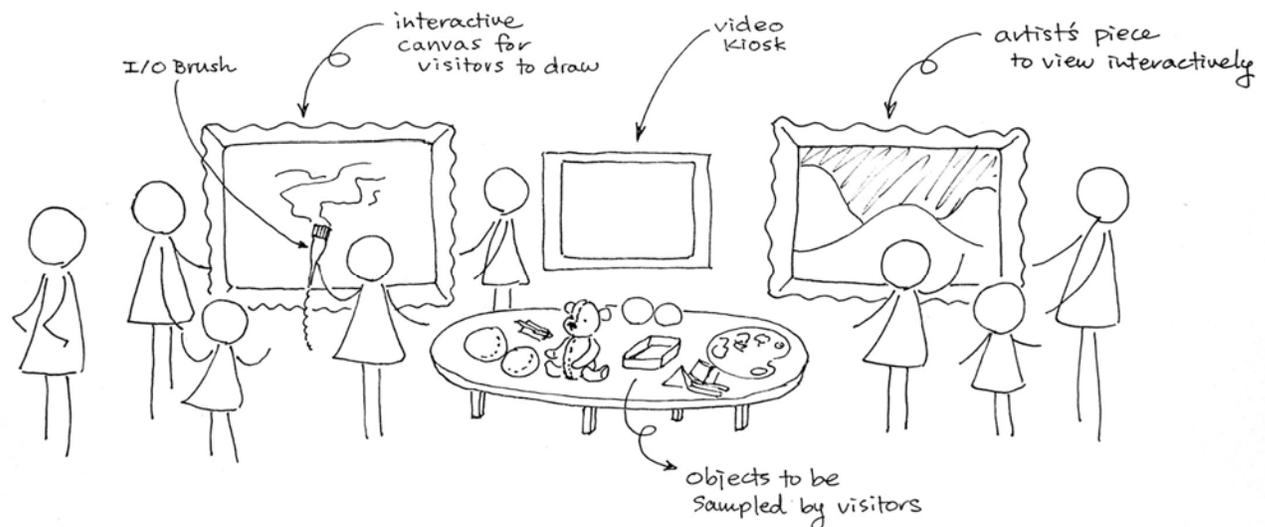
The visitor's canvas (left) is the canvas where visitors can try out the I/O Brush system. The visitors can paint their pictures by sampling colors from their own clothes, body, hair, bags, backpacks, but can also sample colors from the objects presented on the nearby table. The canvas has a "refresh" button (clean canvas, "tabula rasa") so that the visitors can start with a fresh canvas if they wish.

The artist's canvas (right) presents selected previously created art pieces, which visitors can appreciate interactively. This canvas specifically demonstrates the "history function" of I/O Brush. It is interactive in a way that visitors can touch the many strokes of the piece, and the canvas will pop up a short video clip in the area being touched to show the story behind this specific ink. The visitor will not draw on this canvas. Therefore, no I/O Brush is attached to this canvas.

The idea of having two dedicated canvases is to give visitors the opportunity to try out the I/O Brush, but also to present them with a work of art created with I/O Brush. Through appreciating an art piece made with I/O Brush, the visitors may gain new insights about materials and processes that make the art. The third screen is dedicated to a video kiosk that showcases the functions of I/O Brush. This way, the audience can get either a quick overview of the project, or see how I/O Brush works while waiting for their turn to try it out themselves.

TECHNICAL REQUIREMENTS

FLOOR PLAN

Please provide a sketch of a floor plan with metric measurements that shows how you would best like your demo to be laid out at the conference.

250cm

350cm
(230cm minimum)

300cm
(270cm minimum)
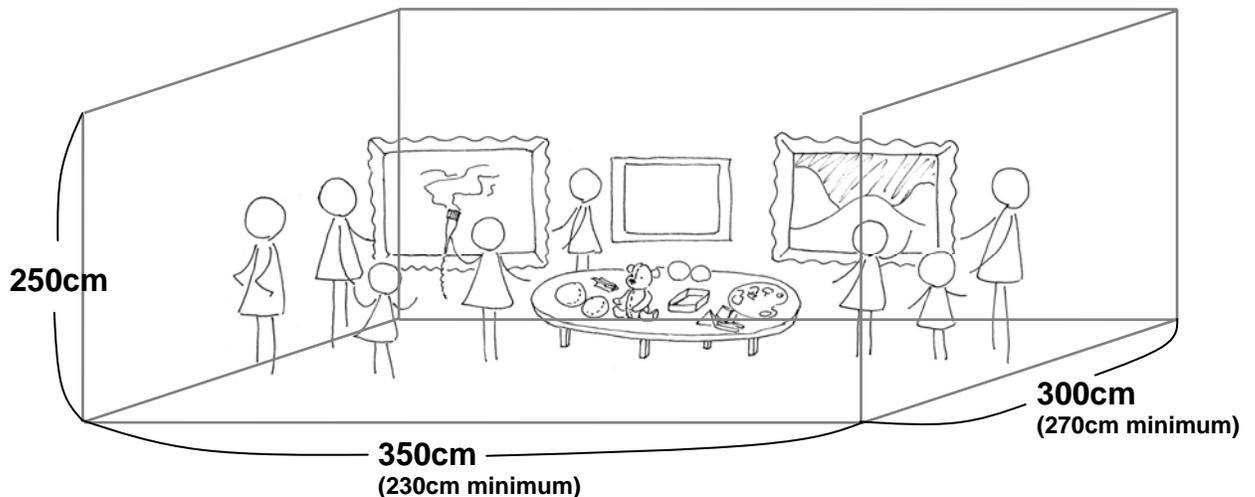
SPACE

Should it operate in two separate locations? Should it be presented against a wall? In a doorway? At a table? In a kitchen? On the ceiling? On the floor? On a tree? Etc?
Does your demo need a special table, chair, carpet, sandbox, etc.?

We will be using plasma displays on stable stands. Therefore, our demo could be placed in any location of a conference room. There is no particular requirement for locations or material for the space.

ACOUSTICAL

Are there special acoustical needs? Does the demo need a quiet space?
Does it produce sound?

Quieter the better in order to show the acoustic aspects of the "history" function, but it is can be shown with background noise as the main interactions does not rely on audio, or rather, the audio can be played back in close range.

LIGHTING

Does the demo require special lighting?
Does it require a dark area?

Although the brush comes with built-in illumination, some spotlight from above onto the table with objects to be sampled would increase the visual aspects of the exhibit nicely.

TIME

Should the demo run only at the opening demo reception or throughout the conference?
Does it work best with a single person at a time? A pair? A group?
Does the demo evolve over the course of the conference or is it self-contained within a 2 minute interaction?

The demo is easily able (stable enough) run throughout the whole conference. At the moment, the system consists of a single brush, so one person can use the visitor's canvas at a time. However, the person drawing usually becomes the 'demonstrator' since the audience in line is watching her in the process. Experience shows that the audience also helps the person drawing with the selection of interesting objects.

COMPUTATIONAL EQUIPMENT

Example questions:
Does the demo involve custom hardware and software or does it run on standard PC's?
Will you be using PC's? How many?
Will you use a projector? A monitor?
What other equipment is needed?
What will you be transporting?
What can UbiComp assist in providing onsite during the conference?

Although the PCs and plasma displays involved (3) could be fairly standard, it may be safe for us to provide a complete system to minimize setup and installation troubles. However, if CHI can provide parts of the non-specific hardware (PC, displays), that will reduce the transportation costs drastically for us. We may have to discuss these issues later in detail. The list of equipment includes:

- 3 displays (at least 1 large plasma as the main canvas)
- 2 touch panel overlays (sizes according to the displays; the main canvas needs a specific type of overlay panel (vision based)
- 3 PCs (more concrete specifications can be provided)
- Speakers
- Colorful and textured objects
- I/O Brush and its custom interface hardware

Tables and extension cords available at the site would be great.

NETWORKING

Do you need to be connected to the Internet? Wired? Wireless? Will 802.11b be used?
How many connections will you need?
What is your demonstration's typical bandwidth usage?

Latency issues?

No networking required for the basic setup.

RADIO FREQUENCIES

Does your demonstration use, produce, or require any radio frequencies? Wireless cameras, microphones, Bluetooth? What frequencies? At what power levels?

There are no RF components involved (or necessary) as of now*.*

POWER

Our demo will need about a dozen plugs for 3 PCs, 3 displays, speakers, and custom hardware.

THANKS!