Tangible Video Bubbles

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Abstract
We introduce the Tangible Video Bubbles, a new video-based drawing space for children to create expressive video art. A Tangible Video Bubble acts both as a container for children's expressions, as well as an instrument with which children can perform with their recorded video by squeezing and stretching the physical bubble. We present our iterative design process and evaluation of the play space with children, and discuss a new approach to making video creation more concrete and playful for children.

Keywords
Tangible, children, video recording and playback, drawings, communication tools, toys.

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

General Terms
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Introduction
Between the ages of five and seven is the period of what Howard Gardner calls "golden age of drawing." Around that age, most children in our society achieve

not only expressiveness in their drawings, but also an easy and natural interaction among various media. The child may sing as she draws, dance as she sings, and tell stories while at play with her toys. Rather than allow each art form to progress in relative isolation from the others, children move readily and even eagerly from one form to another, combining the forms, and playing them off against one another. This could be called the age of "synesthesia," a time when, more than any other, the child engages in easy translations across sensory systems; "when colors can readily evoke sounds and sounds can readily evoke colors; when motions of the hand suggest lines of poetry or lines of verse stimulate a dance or a song." (Gardner, 1982, p.128)

Technology tools that capture children's dynamic expressions, such as microphones, webcams, and video cameras are becoming increasingly available to us at low cost today. Children are fascinated with these capturing devices, actively participating in recording themselves and various things around them with adults' assistance. However, it is still difficult for young children to capture their multi-modal and synesthetic expressions using tools that are generally manipulated through GUI menus. Even a multimodal medium like video lacks tools with the kinesthetic affordances that children find in a paintbrush or set of markers, affordances that allow children to actively construct meanings with a medium.

Our goal is to design, implement, and evaluate a new generation of kinesthetic multimedia tools that support children's "meaning making" through their multimodal creations. Specifically, we explore the design of a new play space where children can create dynamic

Fig 1. Children create video messages and interactive drawings.

interactive drawings using video recordings and playbacks so that they can build on their existing fluency of drawing, but expand their artwork dynamically to share and perform multimodal creations with their friends.

Tangible Video Bubbles

Tangible Video Bubbles introduces a flexible physical vessel that acts as both an input and output device for children to work with videos and easily incorporate them into their drawings. Children can record their expressions into a vase-shaped foam "bubble" and physically squeeze the recorded expression out into their drawing. As they squeeze the bubble in different manners children can edit and manipulate their recording in real time. When children squeezed the bubble near the canvas they can incorporate their recordings in their drawings.

We are exploring a new form factor device to record, playback and edit video messages, making the manipulations of video more concrete and playful for young children. In this paper, we report the design and evaluation of the tangible video bubbles, and discuss the ongoing research effort.

The Play Space

The play space consists a tangible video bubble to record and playback the videos, and an interactive canvas to "spill out" the video bubbles and to draw with.

The tangible video bubble is a large, soft, and huggable ball equipped with a video camera and a screen for children to record and playback video messages (Figure 2). To record a message, the child presses a button on

Figure 2. A child recording and playing with the bubble.

the top and speaks into an opening in the bubble. A video camera inside the bubble captures the child's expression until the button is pressed again to stop the recording. While recording, the child can look at a reflection of herself on a screen in the bottom of the bubble inside. Once a child has captured a message in the bubble, she can play it back at various speeds by squeezing the physical bubble at different pressures. By squeezing, the child can jump to any random location in the recorded message and play it back from that location at any speed. The bubble can also be squeezed in a way so that only a selected part of the speech is played back. For example, if a child recorded "Mary says Hello!" the child can play back a particular part of the message, such as "Mary," selectively by squeezing the bubble a third way through. Repeating the squeeze back and forth three times, the bubble will spill that selected part of the "Mary! Mary! Mary!" in real time.

Figure 3. Tangible Bubble interaction flow.

Squeezing at different speeds creates a slow or fast playback of the video without affecting the audibility of the recording. So the child may play back the recorded "Mary!" message at different speed rates. While in playback mode, the screen inside the bubble visually shows what is being played so that children can check the expression. In this way the tangible video bubble is a physical vessel that acts as both a container to hold the message, as well as an instrument to perform and modify their recorded message to create different expressions.

The width of the physical bubble maps to the length of the recorded video (video and audio). For example, when the bubble is squeezed a third way through (from the outer most to a third way towards the center, as seen in the first illustration in the Figure 3), the first third of the video recording (both visuals and voice) play back. In order to play back only the last quarter of the recording, the bubble must be squeezed to the 3/4 towards the center quickly (the video and audio will play back during the squeeze but they are so fast that they are not detectable/audible), and when the last quarter is squeezed at the normal speed, the video and audio will play back at the recognizable speed.

Once the child is happy with her recording, she may further "spill out" the video message onto a large canvas by placing the bubble on the special "spill platform" near the canvas and "squeezing" the message out. Again, she may squeeze the message onto the canvas at different speed rates, or release selected parts of the message using the mechanical property of the bubble. The speed of the physical bubble squeeze on the physical platform influences the live video and audio playback, but also at the same time, determines the speed of the eventual video playback when the virtual bubble is "popped" on the screen. When the physical bubble is removed from the spill platform, whatever the video and audio playback that happened on the platform is transferred onto the screen as a digital bubble that contains the video and

audio performed on the spill platform. The digital video content then "spills" onto the canvas. The touch-enabled digital canvas allows the child to then touch the graphical bubble to "pop" the content in order to play back the video message. As many bubbles as desired can be added, removed, and moved around on the canvas. A color palette allows children can draw on the canvas as they would on a piece of paper. The bubble and the canvas can be operated simultaneously, so that one child can work on the drawings, while another can work on the video recordings.

Design and Implementation

Hardware Design and Interaction Design

We developed the tangible video bubble through an iterative design process. In a first step, we designed and built two types of vessels: an accordion and a bubble (Figure 4). With the accordion embodiment, the rate in which the accordion's fan-folded bellows were expanded or closed was measured to change the playback speed of the message.

Our evaluation of the initial prototypes with children ages 4-8 revealed that the different vessel shapes, the accordion-like container with bellows and the simple balloon-like round container, elicited different focus and interactions from the children. The bubble, with its simpler shape and its mechanical flexibility, seemed to work better especially for young children. Therefore, we decided to simplify and focus on the bubble as the container shape. The change in pitch during playback mode also seemed difficult for the children to work with, so we decided to focus on modulating only the speed during playback, without affecting the pitch of the original recording.

Figure 4. Our earlier vessels: "Accordion" and "Bubbles."

We also increased the size of the bubble: our original small bubble (7 inches in diameter) was easy for the children to pick up and hold. However, the small diameter required fine motor skills to use, and children did not achieve full control of playback. For example, it was difficult for children to distinctively control "a third-way" through or "a quarter-way" through while manipulating the bubble. We needed to increase the diameter of the bubble to allow children to leverage their gross muscle movement for better playback control. Designers from IDEO (an industrial design consulting firm) ran into similar issues while designing a toothbrush for young children: for small hands, a bigger handle results in more stability and control [6]. To address our users' needs, we constructed a new bubble with 17" diameter from medium density polyurethane foam.

Technical Implementation
A standard USB webcam is fitted with a peephole lens (to achieve wide field of view) and is coupled with Max/MSP/Jitter. Optical sensing of bubble shape does not add any mass to the physical interaction and is reasonably responsive and accurate, allowing the user to squeeze the bubble in almost any way with uniform responsiveness. Green LEDs are sewn around the inside of the sphere while red LEDs line the aperture. The red LEDs are used to define the opening in the top of the sphere and input surrounded by the LEDs is separated from the original feed to isolate the user's video recording. The remaining video is used to measure the user's physical interactions with the bubble: squeezing the sphere pushes the green LEDs closer to the camera and increases the green saturation in the video. With calibration and sensor conditioning, this provides a reliable squeeze sensor.

Users control recording of their messages by pressing a pushbutton next to the opening in the bubble. When pressed, the microphone and video camera record until the button is released. Once released, the user can scrub through the audio and video by squeezing the bubble. The video will preview on a special "preview" area of the canvas. There is an apparent one-to-one relationship between the amount of squeeze and the playback position in the video, and playback allows speed-change without pitch-change to improve the understandability of the recorded message.

Related Work

Tangible container metaphors have been explored in the past [4], [10]. Our tool adds an element of digital manipulation that is controlled by physical manipulation of the container itself. For example, ScreamBody [1] is a human-organ shaped portable container that allows a person to discreetly scream into the container while in public spaces. ScreamBody records the person's scream for later release, at a time of the person's choosing.

Researchers have explored tools for children to record and compose their recordings, as well as to mix drawings. KidPad [3] is a collaborative storytelling tool that supports children creating hyperlinked stories in a large two-dimensional zoomable space. Jabberstamp [7] is a tool for children to embed audio recordings into their drawings created on paper. This tool allowed children to compose and arrange their recordings on a graphical canvas, but did not provide tools for children to manipulate or play with their recordings nor to record video. I/O Brush allows children to paint with video on a canvas but does not focus on means for children to manipulate recordings [8].

Picture This! [9] is a video editing and capturing device designed for young children to craft movies with physical toys and artifacts. As children play with the toys to act out a story, the system analyzes their gestures and play patterns. In their play, children can easily alternate between the role of the characters and cameramen in a film.

The Tangicam [5] is an oversized plastic donut with two embedded cameras that allows simultaneous filming of the child and the images the child is filming. When placed on the multi-touch table, the Tangicam acts as a circular slider for video editing. Children can rotate the ring to browse their images and a timeline, or control video speed. Our work shares the same goal of enabling video recording and editing for young children based on tangible media. Furthermore, our Tangible

Video Bubble, with its vessel shape and mechanical flexibility, contributes a new tangible "input / output coincidence" form where the object is both the controller and the container of video-based media for young children.

Evaluation

After initial iterative design stages with children, our current system was tested by a total of 18 children between ages 4 and 10. At the beginning of each play session, one of the researchers showed the children the basic function of the bubble recording and playback for about 5 minutes, which included demonstration of applying different pressures to cause different rate of playback speed. The researcher then passed the bubble to the children to play with. From then on, the children were free to play with the system for as long as they wanted. There was no explicit practice session to encourage children to master different speed. How the children explored different playback style with the bubble subsequently was up to them. Some spent a lot more time playing with different playback speed than others who some spent more time working on the drawings.

Results

The children quickly got the idea of the bubble, and learned how to manipulate it to record and play back messages. The children took turns, and transitioned easily between playing with the bubble, and playing on the canvas, back and forth, switching smoothly. The children also experimented with the bubble to play back their messages before "releasing" or "spilling" the content onto the canvas for drawing.

Figure 5. Mira's cat meows when touched (by means of playing a video recording Mira made of herself).

Interactive Drawings and Puppets

The children incorporated their drawings into the video messages they created with the bubble. The most common type of incorporation was the children recording a video phrase in the style of a "speech bubble," and then drawing an object on the canvas for the bubble. For example, Mira (age 8) recorded herself saying "Meow" with the bubble, squeezed the "meow" onto the canvas and drew a cat, which she and her partner could interact with to have the cat say "meow" as they touched it (Figure 5).

In addition to creating puppet-like characters on the canvas that came to life with their recorded videos, the children created interactive portraits that were meant for someone to receive and reveal a hidden message. For example, Duane (age 9) recorded several personal messages to his godmother, e.g., "Lety, you are the best!" Duane transferred the bubble to the canvas and drew hearts around the bubbles. Later, he showed his godmother what he had done and invited her to touch and reveal the message behind his creation.

One portrait by an eight-year old consisted of a canvas full of crossed out number 8s. But when one comes close to the portrait and pops the bubble on the canvas, the video message pops out and says, "I am eight right now but in a month I am going to be nine!" revealing the meaning of the portrait.

Playing with Sound Effects

The ability to play back their own video recordings at different speeds using the bubble seemed to inspire the children for the subsequent recording and playback iterations. While working with the bubble, Clara (age 8) accidentally squeezed so fast that her recording towards the end sounded like a fast rattle. Inspired by what she heard, Clara exclaimed, "That gave me an idea! I'm going to do a monkey!" and recorded a monkey sound, "Rrrrr, woo woo!" to go with her drawings.

Five-year-old Keoni figured out that he could create a loud playback sound by blowing into the bubble instead of talking into it (i.e., the microphone inside of the bubble is blown on), an effect which he proudly showed to his partner. He repeatedly experimented with various sound effects that he could create by recording different sounds and playing them back with various forces onto the bubble. For him, it was more interesting to play with the sound effects he could create with the bubble than to spill the message onto the canvas to add drawings. The play space seems to support multiple ways of interaction and different play styles.

Children's Personal Messages

Finally, some children shared some of their intimate and personal messages. One 9-year-old recorded, "I miss my mom. I haven't seen her for more than a year…" Perhaps the private vessel shape of the bubble invited some children to share some of their most personal messages.

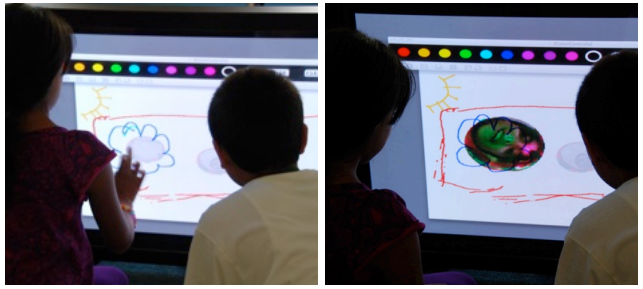

Figure 6. Children creating interactive drawing with video bubbles.

Age Differences

While all children were able to use the bubble to record and play back their video messages, the integration of video expressions and drawings happened at different levels. While the five- and six-year-olds tended to "label" their drawings (e.g., attach a recording of the phrase "Jellyfish!" to their drawing of a jellyfish on the canvas), the seven- to eleven-year-olds were able to add thematic interaction between their drawings and their video messages.

The length of play varied even within the same age group. Some younger children played with the system longer than the older children and vice versa. We did see complexity of interaction between the drawings and recorded videos increased with age (i.e., while video recording of younger children reflected labels of their drawings, older children planned what they would record and how the drawings become supporting part

and vice versa). However, we did not see correlation between the play length and age. In other words, older children were able to create complex pieces regardless of the time they spend with the system.

Future Work

While the children successfully recorded and incorporated their video bubbles into their drawings, there were times when their canvas was filled with many video bubbles and—as there was no mechanism to "combine" bubbles on the canvas—some children ended up erasing some bubbles to make space for their drawings. We plan to update the software so that further edits of the bubbles on canvas are possible, e.g., conjoining multiple bubbles on the screen when they are moved manually in proximity of each other.

Once the bubbles are transferred onto the screen, currently, it is not possible to change the size of the bubble or speed of the playback using just their fingers or using the physical bubble. We are currently implementing the ways to allow manipulation of the bubbles on the screen using the fingers or using the physical bubble.

Additional sensors may be added to the physical bubble so that rotation and acceleration of the bubble can influence how the bubbles spill onto (and behave on) the canvas.

Discussion and Conclusion

Children took turns drawing on canvas and recording personal video expressions with the bubble. In the process, some directed each other (e.g., calling "Action!" to their partners) and coordinated recording messages together into the bubble. For some children, the play space offered a safe place to record personal messages. But most of all, the Tangible Video Bubble turned intangible video-based media into more tangible and "manipulable" media for young children. By giving video-based media a more concrete form, the new play space invited children to create dynamic expressions integrating video and drawings. This work contributes to a new generation of kinesthetic multimedia tools that support children's "meaning making" through their multimodal creations, as well as to the design of alternate input and output device for video message creation.

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