Tangicam: Exploring observation tools for children

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ABSTRACT
This paper describes the design and early evaluation of the Tangicam, or tangible camera, a mobile device for children to capture and edit realistic pictures and videos. Our first experimental results show that the affordances of the Tangicam allow imitation learning and free playing in a context of tangible and augmented reality. Our goal is to create a simple and robust observation system that lets children produce narratives based on situated [51] video, audio and sensor data. We also want to explore how these temporal structures may allow children to describe themselves, other children or natural phenomena and how such situated time series may help develop new forms of synaesthetic and intersubjective constructions.

Keywords
Free play, physical video editing, augmented reality, mixed reality, sensors, self-observation, inter-subjectivity, synaesthesia

INTRODUCTION
Children are fascinated by images: from a very early age, they observe their mothers, their bodies and nearby objects. As they get older, they sketch images to represent absent people or things, using tools such as fingerpaint or crayons, on a variety of media. Such tools are robust, inexpensive and are well adapted to their motor capabilities and interacting with writable surfaces is clearly attractive to young children. Yet these tools limit their figurative skills: pencils, sand and other simple objects are too primitive for producing realistic representations.

If children want to create realistic photographs or movies, they must master devices designed for adults. Digital cameras are often fragile and expensive, with small buttons that require precise motor skills too difficult for young children [21]. Video editing usually requires a computer and understanding of a complex, multi-command WIMP (windows icon mouse pointer) interface intended for adults.

Another problem is that realistic imaging products focus on either capture or editing, not both. Some digital video cameras do offer limited editing functions, but they do not allow simultaneous capture and editing of video. Some computer systems allow live input from webcams into their software, but the webcams themselves must remain in close physical proximity to the computer.

Our goal is to design a simple yet powerful and realistic video capture and editing system for children. Such a system should allow them to switch rapidly between capturing situated content and creating complex narratives. At this writing, the only truly mobile hardware of this type is Sony's Vaio GT3 camera-computer [49].

This paper describes the design and development of the Tangicam, a tangible camera that lets children capture and edit realistic pictures and videos. We begin with a review of the relevant literature, followed by a description of the Tangicam design space and its three working prototypes. We then describe the results of a three-day test of two Tangicam prototypes at the "Fête de la Science", a French national science fair designed to interest children in science and research. We conclude with a discussion of our findings and directions for future research.

RELATED WORK
In the early sixties, Papert and his colleagues at BBN developed one of the first interactive physical interfaces for children. Using Logo commands, children wrote programs to control the movements of a robot turtle [41]. The design embodied the constructionist perspective, described by Ackermann [1] which argues that children need concrete engagement and that they learn by doing, manipulating and exploring physical objects. Unlike other interaction devices of the time, such as chord keyboards, lightguns, and wooden mice, the Logo Turtle fundamentally changed how we think about interfaces for children. The design of Tangicam is influenced by this early work, pursuing a tangible, rather than WIMP approach to children's video editing.

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Digicams for children

A few commercial digital cameras have been targeted at children. Some are bundled as a marketing bonus along with existing toys or products, but they usually suffer from very low resolution and are more appropriate for illustration than taking realistic pictures. Others are instant cameras that print fuzzy images on tiny stickers. Such cameras seem based on the design assumption that children only want "pretend" cameras to play with, rather than devices capable of taking real images. Some children find this very frustrating.

The Human Computer-Interaction literature describes various mobile devices that allow children to record data, including the Dynabook [26], the Communicator [39] and, more recently, appliance environments for creating physical stories, such as [45, 11] and [37]. The Periscope [55], a screen on a pole, placed in the woods, captures information about the local environment which is relayed to a children's classroom. Although not mobile, this use of situated sensor data as a source of input has influenced the design of Tangicam.

We have not found any digicams for children that support editing, although there are a number of such systems for adults, including [34, 18, 20], and [29]. These explore ways of augmenting digital images by adding structured metadata or real-time effects but are not intended to support picture or video sequencing or narrative creation.

Physical video editing

Some systems address physical representation of temporal or event-based structures, including those dedicated to music composition [43, 24], simulation [42], and design [22]. However few have focused on video editing, which is usually viewed as a virtual operation [32]. An exception is *VideoMosaic* [33] which was designed to "lay out time in a physical space". Using an augmented reality paradigm [54], paper storyboards are the interface for controlling an on-line video editor, based on EVA (the Experimental Video Annotator) [30], initially created on the IVIS (Interactive Videodisc Information System). Paper strips are reified [4] instances of video tracks with paper buttons to control editing operations. VideoMosaic used handheld scanners, barcode readers and a small printer to annotate scenario and video content, offering an open environment in which the user can easily arrange and customize the different paper-based elements.

The *LogJam interface* [8] uses small wooden blocks to enable ethnographers to edit their log footage and uses foot pedals to control navigation. The system is intended to introduce fun and creativity into the often tedious and solitary task of video logging.

The *Tangible Video Browser* [23] uses tokens that act as both containers for a set of videos and controllers for selecting a video and navigating within the video. Placing a token on the interface enables access to the set of videos and depressing, releasing, and rotating the token controls the navigation.

The *Tangible viewpoints* system [35] combines an augmented reality table and graspable surrogates, providing a direct mode of navigation within a story world. Using wireless and tag sensing technologies, interactive narratives can make use of rich haptic interactions with physical objects.

Each of these systems separate data acquisition and the editing process, introducing a barrier between perception and action. This digital dualism inhibits emergent and exploratory activities and slows feedback. We developed the *StoryTable* [5], as part of a participatory design process with children that combines data acquistion and editing in the same system. Designed to look like a puppet theater, with a small, attached but mobile camera on top, children can film short video sequences using plastic control strips containing RFID tags. By superimposing the strips, children can merge video streams and overwrite them with new video clips, creating a variety of different effects.

Cubes, Blocks and Tiles

For over twenty years, designers have been developing cubical input/output devices for architecture [2]. Kitamura's ActiveCubes [27] were inspired by the architects Robert Aish and John Frazer and allow children to construct shapes in the real world that appear simultaneously in the computer. They use sensors and actuators for a high level of feedback and can act as logical input devices to perform complex operations. More recently, many cubes and blocks have been designed specifically for children, including AlgoBlocks [52], PhysicalBlocks [3], E-CUBes [10], LogoBlocks [6], Electronic Blocks [56] or System Blocks [57].

However few of these devices have been used for video editing. Yet each have interesting affordances: they are usually three dimensional and often allow direct manipulation of virtual content. Early evaluation of those devices [56] shows that they can serve as proxies between spatial and logical operations. This is an active area of research due to recent advances in materials, particularly sensors and actuators. These devices are the modern versions of Locke, Fröbel, and Montessori sets.

The next section introduces the Tangicam design space for exploring the issues of tangible video capture and editing. We also describe the design of three working prototypes.

THE TANGICAM DESIGN SPACE

We began our design investigations by creating two systems for editing visual data: a progressive controller called MagicWand (“La Baguette Magique”) and a cubical video controller called VideoCube.

MagicWand

The MagicWand (figure 1), is a neon stick equipped with an orientation sensor, developed in collaboration with Emmanuel Nars from an idea by Frederic Vernier. The software was written in C++, using Phidgets [17] and a simple non-wireless sensor interface. A webcam displays an image of the user, who can control the image line by line and in all directions the shutter of the camera. The MagicWand creates images where each pixel is created at a different moment. A child can thus create multiple instances of himself within the same photograph.

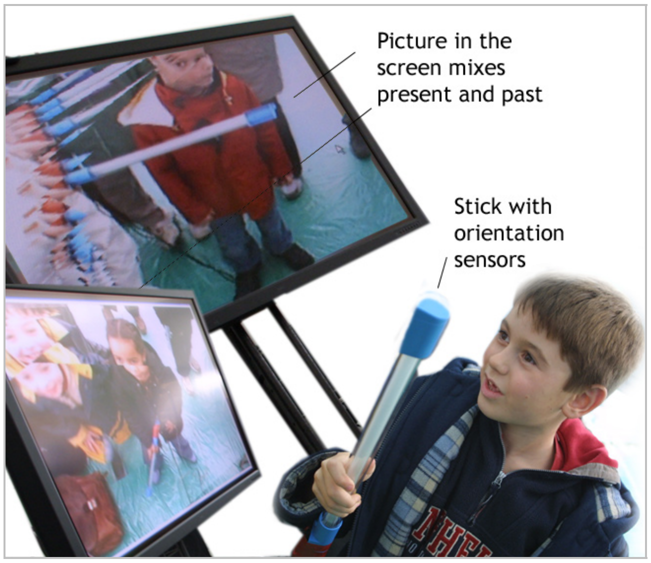

Figure 1: Children experimenting with the MagicWand (*Fête de la Science*, October 2004)

VideoCube

The VideoCube (figure 2) is a simple tangible and wireless controller that remotely controls a video player. Each side of a soft, colored cube corresponds to a simple video command (play, pause, record, stop). When the child turns the cube, the corresponding RFID (Radio Frequency Identification) tag is activated and the child sees the results of the command displayed on a computer screen.

We chose RFID tags because they are inexpensive and safer than other wireless technologies, such as bluetooth or wifi, enabling us to produce a working prototype that we could test with real children. The software was programmed in C#, using phidgets.

Figure 2: (left) Video cube components: RFID tags and wireless controller (center) Videocube input device (right) Screen display controlled by Videocube

We were intrigued by the comments of children who used a similar device, the E-CUBe [10]. They requested handles because the cube was simply too small for two children to carry. We experimented with adding handles to the VideoCube and realized that, for children, the handles can become the primary interface. They serve not only as a stable method of manipulating the camera, but also act to frame the image. The transformation shown in figure 3, hides the standard camera altogether and leaves only a round frame, which the child can use instead of a digicam's tiny view finder to decide where and what to shoot.

Figure 3: A VideoCube with handles was transformed into the Tangicam picture-taking frame, removing the controller and leaving only the handles.

Tangicam

The Tangicam – or tangible camera - is the result of the evolution from the VideoCube with handles into a single, picture-taking frame. Made of rugged, transluscent plastic, the Tangicam is essentially a big circular handle with two embedded cameras (figure 4) that allows simultanteous filming of both the child and the images the child is filming. Inside, an electroluminescent wire glows to provide feedback and to allow filming at night. The Tangicam is designed to handle both mobile video recording and physical video editing.

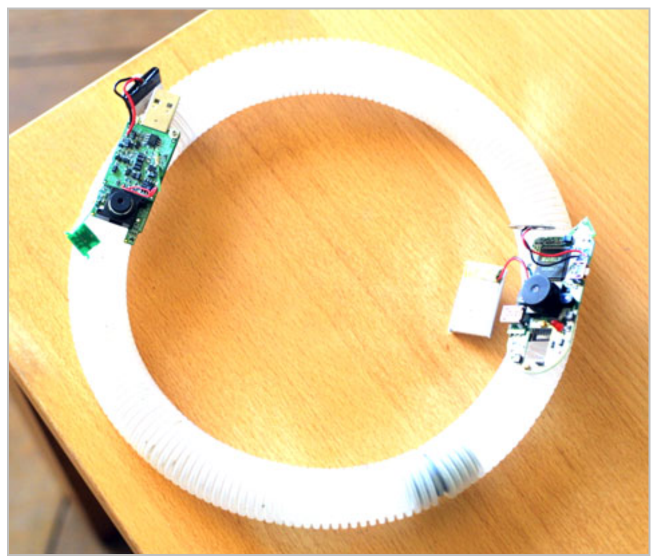

Figure 4: The Tangicam is a transluscent ring with two embedded video cameras (made visible here for illustration purposes).

The interaction is simple enough even for very young children. They hold onto the edges, look through the frame to choose what to shoot, and then press the handles to record. Tangicam is large enough that an adult can grasp the sides together with the child and share in the recording process (figure 9).

Figure 5: Using the Tangicam to frame and take a picture or video clip.

Tangicam is designed to be a normal toy, rather like a waterproof Frisbee™ that glows in the dark. This toy orientation authorizes and allows children to record videos in unusual situations, such as shooting under the water or in the air, or by attaching it to an animal or a vehicle. A toy should not be fragile, but should survive dust and shocks and encourage children to feel in control. Note that, due to time constraints and chip inavailability, the version we were able to test with many groups of children is not wireless, has a USB interface and only one camera.

The current version of Tangicam works with DiamondTouch [47] to display the photographs and videos captured by the children. DiamondTouch is a multi-user, touch sensitive input device developed at MERL (Mitsubishi Electronic Research Lab). Not only can it detect multiple, simultaneous touch events, but it can also identify which user is touching where and the orientation of the Tangicam itself.

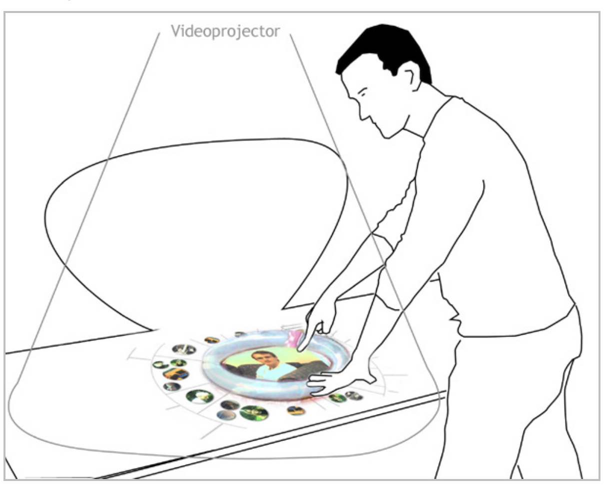

Figure 6: Rotating the Tangicam on the DiamondTouch table acts as a circular slider

When placed on the DiamondTouch table, the Tangicam becomes a physical window or a dynamic picture frame, changing its role from recording to displaying images. The Tangicam can also act as a circular slider (figure 6): Children can rotate it to browse their photographs, zoom in a timeline or control video speed.

We decided to make Tangicam photographs and videos circular to reflect its round frame. We crop standard rectangular images obtained from the embedded cameras and display them in a circular format. This creates both an interesting contrast from the usual rectangular images and also provides new opportunities for visualising temporal data, e.g. spiral structures. We used DiamondSpin [47], a full window manager written in JAVA 2D, that allows operations such as table rotation and circular desktop management, and makes it easy to manipulate and orient circular images.

EVALUATION

We took advantage of the French national science fair, *Fête de la science*, to evaluate the MagicWand and the Tangicam with children. In collaboration with Frederic Vernier, we installed the DiamondTouch table and a large high-resolution plasma at our booth. Over a three-day period, we hosted over 600 children. We took over 500 photographs and two hours of video of them using both two systems. The first day was devoted to groups of school children, grouped by age: five-eight, 10-12, and 13+. The final two days, over the weekend, were reserved for familes.

Method

We prepared several questions, which we asked of each of ten different school groups across all three age groups. We then asked the same questions of ten families with young children, with ages ranging from two to 10. We always began by asking a completely open-ended question: "What is this?" and recorded their responses on video. We then selected a motivated child and explained how to use one of the devices, e.g. showing how to press the handles of the Tangicam to start recording. We then asked the child to repeat what we had just done and show another child how to use the device. We recorded the childrens' explanations of these devices to other children or sometimes their parents.

Results

Affordances

Childrens' answers to the initial "What is this?" question were not technological, despite the context of a science fair and the presence of wires and a large display screen. Instead, they referred to the Tangicam in terms of its perceived affordances [14]: e.g., a hat or a ring. They were fascinated by the glowing wire inside the MagicWand and most called it a magic stick or magic wand.

The names they chose help illuminate how they perceive each object and its possibilities, without being influenced by an adult's prior explanation. For example, they saw the

Tangicam as something one can wear and were delighted to discover that wearing it as a hat resulted in filming the ceiling (which happened to be filled with helium balloons from the next booth).

Figure 8: Children trying out the Tangicam at the *Fête de la Science*, October, 2004.

Children also appreciated the Tangicam's handle affordance, especially when they all wanted to hold it at the same time. We found that the child who controls shooting has to really press hard so as to prevent another child from taking it. We deliberately allowe competition and conflicts, to see what would happen.

We were amazed to find that that Tangicam can be grasped and effectively used by as many as eight five-to-eight year-olds at a time. The one who controls the filming becomes the skipper, using the Tangicam like a steering wheel and fighting off the seven other children trying to take over.

Figure 9: Children controlling the Tangicam.

The version we tested had only one camera and many children turned it towards their faces, filming themselves. We plan to make future versions with two mobile cameras able to film on different axes. For example, the child might simultaneously film his mother, in front of him, while capturing his own face as he takes the picture or video clip.

This would allow children to auto-index their video content with metadata streams constructed of their own facial expressions. An expression-based search engine, such as [9] might then help them find visual sequences associated with those facial expressions.

This could also be an interaction mechanism, allowing children to change their facial expressions to control their data collections in real-time. We expect that children would find this both fun and efficient, since rapidly changing their facial expressions is one their most developed motor skills [36].

Imitation

When we explained the use of the Tangicam, we used a combination of words and gestures to illustrate how it works. In contrast, most children omited verbal explanations and either reproduced our gestures or tried to show original examples, showing what they had created themselves, such as funny perspectives obtained by placing the Tangicam in an unusual orientation or creating a kaledeidoscopic pattern with the MagicWand (figure 10).

Figure 10: "Explaining" how to use the MagicWand by "passing the baton". Clockwise from upper left: (a) She says "I'll show you" (b) "Look, it's me, twice!" (c) She takes it (d) She reproduces her facial expression.

Again, imitation plays a key role in the transmission of group knowledge. Concrete examples and visuo-motor hints are very efficient: Otherwise, we might have been overwhelmed by the children’s questions. Instead, children were very competant at showing their parents, siblings and friends how to use both devices. (figures 5, 8, 9)

Mobile augmented reality

The Tangicam does not include its own screen, but requires the DiamondTouch table to see pictures and videos. We found that some children were happy with the images as framed by the Tangicam, but others also wanted to see the video streams on an attached screen, as they film, like a camcorder. Unfortunately, such screens are often very fragile and require a great deal of battery power. A better alternative would be a see-through Tangicam, with a transflective display that removes the need for a separate display table.

Figure 11: Children touched the DiamondTouch display to write their names on their images

Free play

The plastic aspect of the Tangicam helped children discover and invent interesting filming angles. For example, one group hung the Tangicam to several Helium balloons for a bird's eye view of the room. Others explored the bending properties of objects and suggested that we create a zoom/flex feature. They created a variety of interesting images with the MagicWand, such as a single body with ten arms. Many children realized that the MagicWand is an effective form of crowd control: often the child holding the MagicWand would get other children to do things, simply by controlling their image.

DISCUSSION

Children observe themselves

After observing the children using the Tangicam, we believe it would make a very effective probe, either cultural [15][46], technological [5] or field-trip [55]. Such participant observation could be facilitated by some instinctive and low-intrusive properties of the Tangicam, which would allow people to carry it with them over long periods of time, forming a kind of external memory [48].

To illustrate this idea, imagine that a child films important moments of his life during his ‘pre-operational’ stage. Some years later, while in an ‘operational’ stage, he could edit these very situated and intimate images, like a non-verbal digital diary. Without going as far as introspection, Tangicam could initiate reflexive mecanisms, and act as a *temporal mirror*. Temporal awareness is needeed for effective mastering of the reality principle and is crucial in reflexive action semiotics [53][12].

Observations recorded by the Tangicam are modeled as time series, since video, audio and other sensors provide continuous data streams. This provides the possibility of creating a complex mathematical model of their situation. Just as Papert’s Microworlds simulate logical reasoning, we believe that the Tangicam could simulate sensory mappings based on sensor data and create synaesthetic translations [28]. This opens intriguing opportunities for disabled children to communicate with normal children through sensory modality translations, allowing them to share synaesthetic narrative and games. In this context, an intersubjective and mobile appliance for children would need to be both intermodal [50] but also *transmodal*.

Innovation and creativity by children

Another application of the Tangicam could be to foster creativity and innovation in children's communities. Formal methods like brainstorming, free association, or creative problem solving can be facilitated with video [31]. With appropriate video capture and editing devices, like the Tangicam, an eight-year-old could lead a video-brainstorming session with a group of five-year-olds. In the seventies, Smalltalk-literate children taught younger users how to program games and animations, so why not brainstorming sessions led by children?

CONCLUSION

This paper describes the design and early evaluation of the Tangicam, or tangible camera, a mobile device for children to capture and edit realistic pictures and videos. Even if the Tangicam design space is still a work-in-progress, our first experimental results show that the affordances of the Tangicam allow imitation learning and free playing in a context of tangible and augmented reality. Our evaluations with children have shown that Tangicam's circular frame structure is very easy, even for young children, and provides them a way to observe and describe the world with temporal structures such as video or sensor data streams. By detecting patterns, invariances or similarities in their observations, they can interpret the local environment as a continuous dynamic system.

In the future, we want to study how these temporal structures may allow children to observe themselves, other children or natural phenomena and how such situated time series may help develop new forms of synaesthetic and intersubjective constructions. To achieve these goals, we hope to improve our prototype by adding wireless capacities and mobile augmented reality elements such as mobile paper interfaces, a see-through translective screen or VRDs (virtual retina displays) and develop appropriate temporal visualizations. We plan to use the Tangicam as a therapeutic medium [7], as a communication appliance for intimate social networks [38] and as a situated and long-term technology probe.

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