Sagar Vikmani (63044772)
Saumya Gupta (42805042)

Tangible Memories

Abstract

Journaling events, emotions and memories in a written narration is a common practice among the ‘personal diary’ keepers. These narrations not only evoke self-conversations, but also are a way of a cathartic release. It is also not unusual to record memorable moments on camera, capturing these memories in digital devices to be viewed later via a graphical user interface. We propose a system that lets the users record their memories as well as their narrations in an audio-visual form and associate these memories to tangible objects - introducing TUI in a GUI dominant activity. The aim is to let the users record and preserve these intricately woven webs of thoughts, feelings and memories and interact with it in a tangible way while introducing an element of added fun into the process.

1. Introduction

We propose to design a system that allows users to store and interact with their memories in a tangible and engaging way.

1.1 Objectives

Our objective is to design a system that can allow users to record memories in a more meaningful way. We aim to make a tangible and engaging system for storing and accessing memories. We would like to minimize the dependence on mobile phones and laptops as the only tools to capture and revisit memorable incidents. We would like users to manipulate the physical environment around them to make the interaction more intuitive and engaging. We also aim to mitigate the dependence of screens (mobile phone or computers) from one experience (video recording / diary writing) of our lives. We have built a preliminary prototype that conveys our idea and will test this prototype out with users for their feedback. After that, we will also design a diegetic prototype to convey the ideal solution for our task.

1.2 Relevance, Purpose and Application

We propose to convert the video recording/memory recording/diary writing experience into a tangible and interactive system. We are following the theme of tangible bits [1] and would like to convert the GUI (mobile phone) of video recording into a Tangible User Interface (TUI). We thus move towards the vision of making computing invisible [1] by allowing users to interact not with just the computer but with the physical environment around them. We aim to couple graspable objects with bits of information to achieve an interactive TUI [1]. This would allow people to focus their attention to the present moment rather than trying to take out their phones for video recording or trying to recollect and penning it down later in their diaries. Thus, we shift the experience of recording memories 'from use to presence' [2].

1.3 Inspiration: Inside out

Our work draws its inspiration from the Disney movie 'Inside Out'. We want to create a tangible system like the one portrayed inside Riley's mind for making and storing memories. Each memory has an emotion attached to it and is stored in a ball where the color of the ball signifies the emotion. The balls can be picked up and the memory associated with it is displayed. Important memories are called core memories as they shape the personality of the person. Similarly, in our system, each memory would be associated with a colored ball. The memory can be played by picking up the ball and placing it on the system. The more times a user interacts with a certain memory, the more important it becomes and thus the system gives a visualization indicating the same.

1.4 Application

The tangible memory system would be used to record key events occurring in a person's life. Each video recording would be accessible to the user through the system's TUI. Currently, to save memories, people generally use their phone cameras. These recordings are not accessed much and are hard to identify and organize on the phone. Some people prefer to keep diaries to record events. Yet, diaries also do not provide the affordance of accessing entries easily, identifying important events or recording a memory as it is. Through our system, users will identify key events in their lives and simultaneously send the video clip of what they saw to the tangible memory system. They may also video record straight from the system as well. The user can then interact with the TUI to access the memories and organize them as he/she seems suitable. The memories would also

be organized based on the emotion attached to them and the importance the user gives them.

1.5 Research Questions

Our primary research question is ‘How do people interact with a tangible system designed for storing and accessing memories?’ Through this system, we hope to provide users a tangible form of creativity and self-expression. Based on user testing of our prototype, we would like to know if people would use the system the way it is intended or if they would find other purposes for its use. We also aim to know how a tangible system for recording, storing, and accessing memories compares to other memory management practices.

2. Related Work

The inspiration of the project is the concept behind the movie ‘Inside Out’ [9] where memories are stored in balls and sorted based on emotions and the importance they play in one’s life (core memories).

The primary motivation of our project comes from Phylactery [17], led by Charu Chaudhari and Josh Tanenbaum. Phylactery allows a user to record stories by interacting with different objects. The user can then hear the same story by interacting with the corresponding object. This allows the user to attach memories related to a physical object to the object itself, thus bringing the act of storytelling into the physical world. We decided to enhance this theme by creating a prototype that allows users to record video memories, maintaining a journal, by interacting with tangibles. The technology we use (RFID reader and tags) is similar to that used in Phylactery.

Hirosi Ishii and Brygg Ulmer [1], state that we live between two realms, the physical environment and the cyberspace. However, our interactions out largely GUI based. They put forward the need of moving interactions away from desktops, mobiles, laptops, other screens towards the physical environment around the users since GUIs do not make use of the haptic skills that people have developed through a lifetime of interaction with the physical world. They establish the term ‘Tangible User Interfaces (TUIs)’. They believe that “TUIs will augment the real physical world by coupling digital information to everyday physical objects and environments”. They also coin the term "Tangible Bits" and describe it is “an attempt to bridge the gap between cyberspace and the physical environment by making digital information (bits) tangible”. Supporting the same theory, we propose a

tangible and playful UI for memory/video recording/ diary keeping. The current act of video recording is completely GUI dependent. Users record videos on their mobile phones and hardly ever access them again. It is also difficult to find the precise recording one is looking for. Diaries are handwritten or can be maintained digitally as well. Our memory storage system will give a tangible UI to the task of video recording / digital diary writing. The balls in the system act as 'tangible bits' holding the information of the recording inside them.

Our work is also inspired by Bishop's marble answering machine [1]. In this system, incoming voice messages are stored in marbles. The user can grasp the marble and drop it into an indentation in the machine to play the message and manipulate the marbles in other ways as well. Similarly, we have also embodied video recordings into colored balls for making digital information tangible.

In our system, we have also applied theories from the 'Emerging Frameworks for Tangible User Interfaces' by Brygg Ullmer and Hiroshi Ishii [3]. They develop an interaction model for tangible interfaces call the MCRpd model. They carry over the 'model' and 'view' elements of the MVC model and divide the view components into physical representations (rep-p) and digital representations (rep-d). The control aspect is shifted into the physical world. Thus, MCRpd highlights the TUI's integration of physical representation and control. Our system fits well into this model. Following this framework, our system is designed to have a constructive-relational approach. In relational approaches, the sequence, adjacencies, or other logical relationships between systems of physical objects are mapped to computational interpretations. In construction frameworks, a constructive assembly of modular interface elements,
often connected mechanically are mapped digitally. Some systems are a mix of both these approaches such as Triangles [15]. Further details of how our proposed solution fits into this framework are given in the design section.

The Living Memory Box [4] presents a device and service to assist families in preserving memories in a variety of media forms. Since this study had a goal very much similar to ours, we have tried to satisfy some of the key findings stated in this study. Users wanted to remove the work aspect from collecting, annotating and revisiting memories and develop it into a form of personal expression. Users wanted the inclusion of physical objects as a primary feature and move away from the PC. They wanted to develop natural ways of interaction (touch and voice). Storytelling was also an important aspect that was encourages. Our proposed system caters to all these requirements.

Philip Ross and David V. Keyson [2] talk about transforming task oriented deign to experience driven design. They state the interactive systems should consider the total

experience of fulfilling a task. They state that ‘Social, personal, and emotional engagement as well as expression are salient factors in interaction, along with ease of operation and efficiency.’ This is precisely what we aim to bring in through our memory storage system.

Holmquist et al. [5] state that tokens should be designed such that properties of the data associated with the token can be reflected. Also, they should provide affordances for the user to carry out tasks. We believe, color coding the balls provides visual information to the emotion linked with the video recording of the ball. Also, the affordance of opening a ball to place more balls inside it provide the user the flexibility and freedom of creating a memory with different elements.

The mediaBlocks [6] design provides an interesting solution to identify the content stored in a block. The system provides a screen where the block can be placed. The screen then shows the thumbnail of the content. Similarly, we have proposed that in our system, the user can view the thumbnail of a memory on the screen and can quickly rotate between different balls/thumbnails so that he/she can find a memory easily.

Allen defines lifelogging as a comprehensive archive of an individual's quotidian existence, created with the help of pervasive computing technologies [12]. Our prototype is not a traditional life-logger since it gives the users the freedom of choosing which recordings they want to save, while discarding the others. Also, we have designed the system such that the memories recorded are meant to be personal, hence there is no way to share the recording on the internet. The only way anyone can access the clip is through the physical ball itself. This design addresses many concerns raised by Allen. She states that because of such lifelogging systems people with a traumatic past may be subject to viewing those memories exactly in the same way as they occurred, thus being vulnerable to psychological hazards. Even if they choose not to view the recording themselves, they cannot stop others from making them publicly available. She is also concerned about publicizing humiliating moments occurring in one’s life. A person trying to leave a scarred past behind to start a new life may be a victim of his/her old recordings made public. Since our system lets the user decide which recording to keep rather than keeping a log of the individual’s entire life, the system nullifies most of these problems. Also, the solution does not allow the clip to be shared with anyone else. Dodge and Kitchin [14] state that lifelogs would be owned by a person only and we stand by this claim. With this approach, we mitigate the concerns that Allen raises.

Kirby coins the term ‘diegetic prototype’ to account for the ways in which cinema uses fiction or ‘diegesis’ to depict the vision of a future technology [10]. We borrow this idea from Kirby to put forth our idea of what the ‘Tangible memory’ would look like by building

a diegetic prototype without having the need to build the actual system. By putting it in a narrative construct, and an imaginary interaction of an ideal system with a fictional character, we intend to highlight our vision of usability and benevolence of our proposed system and contextualize the system within the social sphere. Also, since our ideal system' requires some futuristic technological implementations, technology that may well be ahead of our time, we take the help of a diegetic video to illustrate our idea of Tangible Memories.

3. Proposed Solution, Design Decisions and Methodology

3.1 Inside Out design

Before diving into the solution, we would like to explain the way memories are portrayed in the movie 'Inside Out'. Each memory that is created inside Riley's mind is stored in a ball. The color of the ball signifies the emotion attached to the memory such as happy, sad, angry, fear and disgust. The important memories are called core memories, these memories shape up Riley's personality. To view an old memory, the ball is picked up and the memory is projected. An old memory's emotion can change based on how Riley feels in the present moment.

3.2 Current Prototype

In our current prototype, the user sits in front of the setup to record new memories. The user interacts with balls to record or view memories. Each ball has an RFID tag inside it, thus each ball has a unique identifier. The user first presses a button signifying the memory's emotion. Currently, there are three options: happy (green), sad (blue) and angry (red). Once the user selects an option, the system finds a ball of the required color and drops it in a slot that holds the RFID reader. This has been achieved through two motors and a color sensor attached to an Arduino board. The other balls are discarded by the system and can be used again for a new memory. After the ball lands in the RFID slot, the webcam of the computer attached to the system, automatically turns on and starts recording. Once the user is done narrating the memory, he/she can simply pick up the ball from the slot to stop recording. A storage to keep the balls with memories has also been created. The storage is divided into slots, where each slot is dedicated to a particular ball. Once the user is done recording, an LED in one of the slots lights up, signifying where to keep the ball. The color of the LED matches the emotion of the memory. Labelling space has also been provided in the slots that can be used for better organization. To view the memory again, the user should pick up the ball and place it back in the slot with the RFID Reader. The computer then plays back the memory associated with the ball. Each time the user plays a particular memory, the LED in that

ball's slot turns brighter, signifying that the memory is an important one, thus mimicking the concept of core memories. Given below is an image of the system.

Figure 1: Current prototype system

Coming back to our discussion on Emerging Frameworks for Tangibles [3], we will define how our system fits well into the MCRpd model. The balls are physical representations (rep-p) with which the user can control and manipulate digital information that is the video recordings. These balls act as 'containers' for the video recordings. The audio and video projections are digital representations of the recording (rep-d). The balls represent recordings, and the color of the ball ties to the emotion of the memory thus providing a relational framework.

3.3 User Tests

So far, the system has been tested out with 7 users where they were asked to record and access their memories. These users were graduate student at UCI and the test was performed inside a lab setting. The system was introduced as a tangible way of accessing memories inspired by the movie Inside Out. After giving a quick overview of the components, users were asked to record and play their memories. They were given additional time at the end to explore the system more. They were asked about the overall experience with the system, their suggestions and how they would use the system if it was kept at home. We received a positive response as the users enjoyed interacting with the system. A few users struggled to take out an old memory from the storage due to the design of the box. For the next prototype, the box will be lower in height for easier accessibility and the LED will be outside the box for better visibility. One of the users thought that a more robust system would enhance the experience. We also observed that a few people were hesitant to sit in front of a camera and record. We have proposed a solution to tackle this problem in out diegetic prototype. Many users were intrigued by the motors and color sensing mechanism. One of the users tried to test out the color sensor as she said, "*So, it can recognize the blue ball even if I mess up the sequence. What if I put two blue balls? Oh, this works*." Users also played around with the balls and gave us more ideas for the dynamic color detection. One of the users wanted to record a narrative on top of her memory. This too has been taken care of in the diegetic prototype. While a few users understood how to record and view the memory quite fast, some users were still trying to access the laptop to control the video. In hindsight, we should have made only the screen of the laptop visible to the users. This also shows that people have tuned themselves into the way technology has been made. Rather than interacting with tangibles which is more innate to human behavior, they prefer to interact with laptops as that is the way technology has been designed, and they adapt to it. By creating such tangible systems, we hope to make technology fun and intuitive to use. In the end, users were asked if they would use the system in any other way. Most of the users found the idea of using it as a personal video diary interesting. One suggested, that it could be used in houses where the family members don't see each other much due to their busy lifestyles. It could be used to leave messages for each other and the color coding would help identify which message is for whom. They also came up with ideas such as dream recording, child therapy and making to-do lists.

3.4 Diegetic Prototype

To describe the 'diegetic prototype' [10], we would like to take you through a story on how a user interacts with the memory recording system. Situating a new technology within a narrative [11] would help us to envision the usage of this system.

On a warm Saturday afternoon, Riley sits near the community swimming pool reading a novel. She still prefers reading an actual book rather than using her IPad or laptop. She wears her 'pair of smart' glasses, the glasses intelligent enough to give her the right lighting. Her daughter Annie, is playing with her friends in the pool. On such afternoons, Riley keeps the recording option of the glasses on. The glasses record what she sees every twenty minutes and then discard the content in due time. "Mom, look what I just learnt!" Annie, shouts out. Riley watches her do a somersault in the air and jump into the pool. "That's amazing honey!". Riley gestures her smart glasses to send the last minute of the recording back to her memory system at home so that she can save Annie's somersault. She gestures that this memory is a happy one.

Back at home, a transparent ball comes out of a box and slides into the center of the memory recording system. A unique pattern of yellow LEDs in the center lights up, indicating that a new happy memory is being created. This pattern is unique to the memory. The ball is lifted onto a dais, the memory is stored into the ball and simultaneously the ball turns yellow. Once this is done, the ball slides down the center and awaits Riley's return.

"Riley! Is that you?" Riley turns and sees a familiar face. She nods as the woman approaches her. At that very instant she recognizes her as Mia, an old-school friend whom Riley had lost touch with over the years. Sure, social media helps them stay connected just like the other 800 people she is connected to. But the happiness Riley feels at that very instant is unmeasurable. Mia and Riley catch up and tell each other about their current lives. The women reminisce their old-school days and laugh remembering the carefree times. Mia tells Riley that she recently moved into the locality with her son Connor. She tells Riley about her recent divorce and the conversation quickly takes a serious turn. Riley listens to Mia's story and sympathizes with her. She admires her friend for her strength and bravery. As the sun goes down the women head back with their children to their homes. Riley promises Mia that they will keep in touch. She sends the last 20 minutes back to her memory system at home as she wants to keep this memory of meeting her friend.

Another transparent ball slides into the center of the system, buzzing with LEDs, stores the memory and waits for Riley.

Back at home, Riley gets dressed for the evening. It's a Saturday tradition that the family goes out for dinner. Her husband John is working today but he promised he would make it on time for dinner. While waiting for her husband, Riley heads to her study and decides to spend some time with the memory system. She sees two balls sitting at the end of the slide. She picks up the yellow ball and places it on the center where a unique pattern of

yellow LEDs starts dancing. She sees the video of Annie's somersault being projected on the screen. Riley smiles and decides to give a funny narrative to the memory. She picks up a smaller audio ball and places it in the audio slot. As the video plays on, Riley starts narrating her story about how quickly Annie is learning new things. She then opens the yellow ball, and places the audio ball inside it. The audio now belongs to Annie's somersault memory. She plays it once again listening to her own voice on top of the video. She places the ball with the others in the storage system. Riley then picks up the other transparent ball. She sees her conversation with her friend. Although she loves the fact that they met after such a long time, Riley feels sorry about her friend's situation. She presses the sad (blue) button and the LED inside the ball lights up as blue. The pattern glowing in the center turns blue as well. She picks up the ball and labels it as 'meeting Mia' and places it with the other balls.

Riley's phone starts buzzing and she sees John calling. "I am so sorry Riley, I am still stuck at work, I think we should cancel today's plan." Riley, all dressed up, acknowledges, and hangs up the phone. She is vexed as this is not the first instance that John has cancelled. She needs to vent and hits the angry (red) button. A unique red pattern starts to glow and a red ball comes along with the hope of containing all her anger. Riley's recording is projected on the screen while she continues to vent. Once she is done, she decides to distract herself and opens the memory storage. She opens one of the old trays and rotates the knob attached to the tray. A preview thumbnail of the memory associated with each ball appears on the screen as the balls in the tray rotate synchronously with the knob's movements. She sees a thumbnail of a family vacation. It is a yellow (happy) ball and is much brighter than the others, Riley quickly realizes it is one of her most watched memories; she often plays this memory when she feels a little apprehensive. She picks it up and places it in the center. A memory of the three of them in Disneyland is projected on the screen. Riley smiles, but feels anxious about the fact whether John would ever have the time of creating more of such memories. She presses the green button, the ball turns from yellow to green, glowing a little brighter than before, turning the happy memory into an anxious one.

3.5 Design Decisions

The diegetic prototype allows a user to send memories that our captured in real time through an intelligent wearable. An example of such a wearable in today's world is Google glass. In the future, we believe that such glasses would have a feature of recording what is being seen, and providing an option for saving the last few minutes of the recording. This allows the users to enjoy the present moment rather than reaching out for their phones to capture the same. The system also allows the user to sit in front of it and record, thus acting as a personal journal. The dual nature of the system takes care of the fact

that some people may be uncomfortable with recording a video of themselves in front of the camera. According to recent studies the four universally accepted basic human emotions are happy, sad, angry and fear [7]. We have used these 4 emotions and associated colors to them per Plutchik's Color Wheel of Emotion [8]. Happy is yellow, sad is blue, anger is red and anxiety is green. We have also given a 'none' option so the user has the choice of not associating an emotion at all or not telling the glasses the emotion of the memory. Once the ball slides into the center of the system, the ball is raised onto a dais. A pattern of unique LEDs lights up in the color of the ball. This design mimics the way memories are created in the brain. A unique path of neurons transmits a signal when a memory is created and each time it is remembered the same path comes into action [16]. Similarly, a unique path of LEDs is linked to every ball in the system, which lights up whenever the particular ball is kept on the dais. Memories are formed when bits of visual, olfactory, and auditory pieces come together. Therefore, we have given the user the option of adding an audio narrative to a memory recording. To add a narrative to an existing memory, a user can place a small ball on the audio dais provided, and start narrating while the memory in the bigger colored ball placed in the center is playing along. Once the user is done, he/she simply must place the smaller ball inside the bigger memory ball by opening it. Thus, this audio ball now belongs to a particular video recording and is played along with the video, every time the bigger ball is accessed. To get rid of the audio recording, the user simply has to open the bigger ball and throw out the small ball, thus leaving the original video recording intact. More than one such smaller balls can be placed in a bigger memory ball. In future, maybe a small ball signifying olfactory or any other type of information can be placed inside the memory ball as well. Since the user gets the freedom of constructing a single memory with different elements, this design ties well with the construction framework of tangibles as suggested by Brygg Ullmer and Hiroshi Ishii [3]. Thus, with the colored balls signifying emotions of memories and with the smaller balls placed inside them, the system falls into the constructive + relational category defined by Ullmer and Ishii [3].

Emotions associated with memories can change when a person recalls a particular memory with a different emotion. Thus, the system gives the user the option to change the memory. Core memories are the ones that are most important to a person. Therefore, in the system, the more a user accesses a memory, the brighter it gets. Memories created by the intelligent pair of glasses line up at the bottom of the system so that the user can return and view the memories. If the user does not wish to do so, then, when more memories are made, the new balls push the previous ones into the storage. Thus, the system does not demand attention from the user and is meant to be used at leisure. The storage is organized into trays where one tray can signify a month or any other time the user chooses. The knobs attached to each tray allow the user to quickly view the content of each ball through thumbnails presented on the screen. As the knob rotates, so do the

balls in the tray, presenting one thumbnail at a time, thus giving the user fast accessibility even when the user decides not to label the balls. This idea is inspired by Mediablocks [6] where a screen displays the content of the Mediablock in the form of a thumbnail.

Given below is an image of how we have envisioned the diegetic prototype

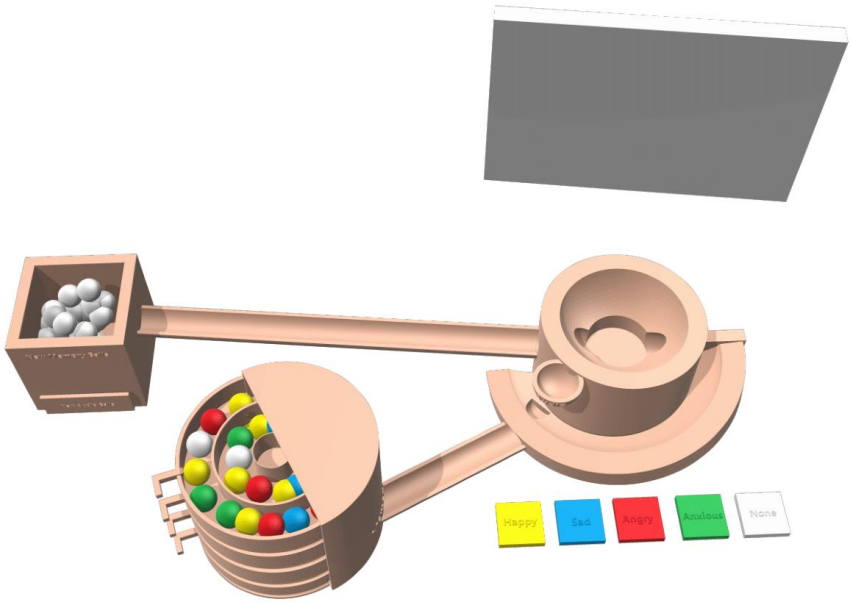

Figure 2: Diegetic prototype (Final design vision)

4. Conclusion and Future Work

Through this memory recording system, we hope to introduce tangibility in the act of video recording and diary keeping. Memories would no longer be lost in the folders of one's mobile phone or laptop. Rather, they would be accessed in a fun and meaningful way. This will promote users to look back into what they have recorded which can lead to deeper reflection and growth. It can also become a family activity, strengthening the bond between them. With the integration of a smart pair of glasses, people would not have to

reach for their mobile phones when an exciting event is taking place. This supports the idea of shifting the task of video recording from ‘use to presence’ [2].

We aim to shift our testing of the primary prototype from the lab into a home environment. We would like to leave the prototype with families for a few weeks to see how they interact with the tangible system. Through this study, we will be able to answer our research questions on how people interact with a tangible system that supports recording, storing and accessing memories, how this interaction compares to other memory capturing practices and if people use the system for other purposes as well.

A challenge that has not been addressed completely in the model is the issue of privacy. Since the design does not permit the recordings to be shared publicly, we mitigate the risks raised by Allen [12]. The system is nearly as safe as a traditional video camera device would be back a few years back. However, there are still a few concern worth mentioning. Would people allow an intelligent pair of glasses to record the events of their daily lives? What if someone else is recording them without their knowledge or permission, just like Riley records her conversation with Mia? By a legal standpoint [13], in some states, an individual is prohibited to record a two-party conversation, without the other’s consent. To address this, the design may have a light indicator on the glasses which glows every time the recording option is on, thus providing visual indication to everyone interacting with the owner of the glasses. However, this concern still arises when a third person records an interaction. This act is illegal nearly everywhere [13]. Yet, in present times, people in public spaces are cautious of the fact that they may be on camera, and hence act accordingly. The issue of physical theft of the ball to access someone’s memory is also prevalent. A memory recorded by an individual, not meant for anyone else, maybe seen by another member of the family if they have access to the system.

Despite these concerns, this project aims to bring a magical element to the mundane task of video recording. In future, we hope that designers create fun and engaging experiences by designing tangibles for other activities as well.

References

[1] Ishii, Hiroshi, and Brygg Ullmer. "Tangible bits: towards seamless interfaces between people, bits and atoms." *Proceedings of the ACM SIGCHI Conference on Human factors in computing systems*. ACM, 1997.

[2] Ross, Philip, and David V. Keyson. "The case of sculpting atmospheres: towards design principles for expressive tangible interaction in control of ambient systems." *Personal and Ubiquitous Computing* 11.2 (2007): 69-79.

[3] Ullmer, Brygg, and Hiroshi Ishii. "Emerging frameworks for tangible user interfaces." *IBM systems journal* 39.3.4 (2000): 915-931.

[4] Stevens, Molly M., et al. "Getting into the Living Memory Box: Family archives & holistic design." *Personal and Ubiquitous Computing* 7.3-4 (2003): 210-216.

[5] Holmquist, Lars Erik, Johan Redström, and Peter Ljungstrand. "Token-based access to digital information." *International Symposium on Handheld and Ubiquitous Computing*. Springer Berlin Heidelberg, 1999.

[6] Ullmer, Brygg, Hiroshi Ishii, and Dylan Glas. "mediaBlocks: physical containers, transports, and controls for online media." *Proceedings of the 25th annual conference on Computer graphics and interactive techniques*. ACM, 1998.

[7] Jack, Rachael E., et al. "Facial expressions of emotion are not culturally universal." *Proceedings of the National Academy of Sciences* 109.19 (2012): 7241-7244.

[8] Plutchik, Robert. "Emotions: A general psychoevolutionary theory." *Approaches to emotion* 1984 (1984): 197-219.

[9] Disney and Pixar's Inside Out

[10] Kirby, David. "The future is now: Diegetic prototypes and the role of popular films in generating real-world technological development." *Social Studies of Science* (2009).

[11] Tanenbaum, Joshua. "Design fictional interactions: why HCI should care about stories." *interactions* 21.5 (2014): 22-23.

[12] Allen, Anita L. "Dredging up the past: Lifelogging, memory, and surveillance." *The University of Chicago Law Review* 75.1 (2008): 47-74.

[13] http://www.dmlp.org/legal-guide/recording-phone-calls-and-conversations

[14] Dodge, Martin, and Rob Kitchin. "'Outlines of a world coming into existence': pervasive computing and the ethics of forgetting." *Environment and planning B: planning and design* 34.3 (2007): 431-445.

[15] Gorbet, Matthew G., Maggie Orth, and Hiroshi Ishii. "Triangles: tangible interface for manipulation and exploration of digital information topography." *Proceedings of the SIGCHI conference on Human factors in computing systems*. ACM Press/Addison-Wesley Publishing Co., 1998.

[16] http://www.the-scientist.com/?articles.view/articleNo/41435/title/How-a-Memory-Is-Made/

[17] http://interactions.acm.org/archive/view/january-february-2017/augmenting-reality-for-augmented-reality