Tangibles and Storytelling

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ABSTRACT
Tangible User Interfaces (TUI) are systems with the goal of giving a physical aspect to accessing information from a digital medium. Combining physical interactions with digital information in order to evoke a sense of interactivity and control over a system. Coupled with storytelling, these user interfaces become potent information relays, as well as being effective edutainment tools for younger audiences. This is because of physical interactions are extremely significant in providing stimuli for the memory, thus facilitating learning.

In this paper, we discuss and evaluate several different research papers about various different tangible user interfaces designed to facilitate interactive narratives and storytelling. These systems provide insight to the dynamics of interactive storytelling, and how these tangibles can be used to deliver non-linear storylines and detach the users from the role of a passive observer to an active role in the stories.

Each system offers fresh intriguing steps taken to reinforce this interactive experience, but with common shortcomings that can be traced back to the physical artifacts utilized in the storytelling. Care must be taken when bridging the virtual world with the physical devices used for interaction, and they must be influential and unobtrusive to the user as well.

Author Keywords
Tangible User Interfaces, Interactive Narrative, hardware technology for interaction and entertainment

ACM Classification Keywords
H.5.2 User Interfaces - Input devices and strategies

General Terms
Design; Documentation

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INTRODUCTION
Tangible User Interfaces (TUI) are user interface systems aimed to increase immersion and interactivity by giving a physical aspect based on touch sense to access information from a digital medium. By combining physical interactions with digital information, tangible user interfaces are able to evoke a higher level of interactivity and control over a system. This can obviously be utilized in many varying disciplines and professions, however, in recent years research and theoretical designs have been developed with the intent to enrich the users' lives through storytelling.

Coupled with storytelling, these tangible user interfaces become potent information relays, as well as being effective edutainment tools for younger audiences. Once the users were detached from the traditional observer's point of view, stories became much more engaging and entertaining.

A multitude of new input strategies and devices have been developed around a TUI, and various studies executed upon these new interfaces have shown the potency of tangible user interfaces, and their ability to engage a user within a storytelling environment.

BEGINNINGS AND SHORTCOMINGS OF MODERN INTERACTIVE STORYTELLING
Ever since computers began to transcend into mainstream use and multimedia, interactive storytelling existed. No longer limited by the traditional linear progression of books and other texts, interactive adventures began to surface around the 1970s within the computing medium. These were generally considered as the founding fathers of adventure computer games, such as Zork and other Multi-User Dungeon (MUD) games [6]. Users were able to traverse these games based off their interactions with the system.

While interactive storytelling is not a particularly new medium of computing, they tended to be strictly bound within the confines of the computer screen, and interactions limited to what a user can do once they are provided with a mouse and keyboard. Despite initial advancements from the earliest adventure games, such as moving from text-based narratives to fully rendered visuals and audio delivered stories, we are still limited by our mode of interaction with the system. Modern user interfaces for interactive storytelling and adventure games, such as Gemini Rue [7], are still leaning more towards the user giving a set of limited commands to the system that somehow progresses

the storyline. There was no meaningful involvement of the user in relation to the story, and an interactive storyline that could be physically more involving was degraded to a somewhat glorified movie where the user has to input arbitrary commands to the system in order to advance. Another example of this was Carmen's Bright IDEAS [1], where the storyline was advanced through the user selecting various different conversation options for dialogue.

In recent years, more studies have been aimed towards breaking and extending this interaction paradigm, constructing what is known as tangible user interfaces; systems that provide more immersive and dynamic interactions than the keyboard and mouse.

Figure 1. Despite initial advancements, modern user interfaces for interactive storytelling are still limiting in the actual physical interactions (Screen capture from the interactive story adventure game Gemini Rue [7])

IMPLICATIONS OF TANGIBLE USER INTERFACES

The key aspect of any interactive storytelling system utilizing a TUI is how they allow for non-linear narratives to be told to the user. "*The presentation of a narrative can be thought of as movement through a narrative space. In a non-linear narrative there is more than one way to traverse that space*" [1]. In any traditional storytelling medium, the audience was bound to a linearly progressing storyline. With no means of interaction or input, users are condemned to become passive observers to an advancing narrative. Even when allowed to interact with the storyline, current interactive storytelling systems lack in either variety or immersion in the interactions. These are obvious and unavoidable pitfalls when considering the mode of interaction the audience was usually limited to: the keyboard and mouse. An example of this was the FearNot! [1] interactive story, where the user plays a friend of a bully victim. Interactions with the bully victim such as suggesting to the character how to cope with the bullies, although interesting, was limited by keyboard input.

The role of tangible interfaces and its relationship with storytelling is to break this interaction barrier and allow for users to become more than just passive observers. Providing users access to physical artifacts that are integral to the storyline, and can directly influence the narrative, counteracts the conventional isolation of reality and the virtual story world, encouraging the audience to take a more active role [6]. By encouraging more and more active roles within the story world, tangibles can allow for extra levels of interactivity, resulting in true immersion for people using the interface [2].

In order to achieve such level of interaction, tangible user interfaces that support an interactive storyline must represent a very significant part of the story itself. This interaction must also find a fine balance between the user's ability to change the course of the story and the actual intent of the author of the story. Even though the users are now active roles within the narrative, they must not be allowed to become lost, either due to a convoluted branching structure for the story or an awkwardly presented physical interaction from the tangible [1]. This also presents a very challenging and interesting paradigm for the authors of interactive stories. While the audience has transformed from passive observers to active roles, the author in turn must transform into a pseudo-director and narrator for the story, providing interweaving narration possibilities, yet carefully moderating them, using a balance of constraints and branches, so not to lose a cognitive narrative structure and result in the audience becoming confused.

Another key decision for developing an interactive storyline supported by a TUI is the mode of interaction. This is, more often than not, limited by the technology available, as well as the imaginations of the creators of the TUI. Not only does the physical tangible be relevant to the story and provide extra immersion, but it must also be easy to use and familiar enough to the user to pick up and know immediately how to utilize. "*Objects in the real world become gateways to the virtual narrative experiences. A participant can use a pen, which, in the virtual world, may turn out to be a fantastic magic wand. The reality of the physical world can be challenged, and somehow augmented with this new form of interaction*" [1].

The result of all of these changes to the role of users, authors, narratives and perspectives was an added layer of dynamic interaction. All roles and interactions effectively become dynamic, changing entities that break the barriers of traditional storytelling standards. Such interactions have lead to new technologies and user interfaces that challenge the storytelling medium and hints at future educational and entertainment possibilities.

EXISTING EXAMPLES AND APPROACHES

In order to construct a successful TUI, users must be able to influence the outcomes of the system. However, one must think a step further to fully implement an interactive storytelling tangible interface. The creators must decide

what physical artifacts should be used to bridge the real with the virtual as well. There are many different examples of existing approaches to meet this criteria, each more intriguing than the last.

Initial approaches to tangible user interfaces often incorporate existing physical interactions that people are already familiar with. An example of this was The Story Builder, produced by Lego [1]. Children can construct various stories through the use of plastic cards. Combinations of these cards can be inserted into the story builder via several slots on the top of the device. Different card combinations corresponded to different possible storylines for the device to portrayal. Another card based TUI was the Papous storyteller [1]. Cards are inserted into slots in a box, which influences a virtual old grandfather figure known as Papous. Depending on what cards were inserted, Papous would narrate various differing stories through the computer.

Both card based interactions rely on the cards to change the characters and locations of the story, with Papous going as far as being able to change the tone of the storytelling ranging from joyful to sombre depending on card inputs.

Figure 2. Depending on what cards were inserted, differing stories will be narrated (Physical interactions through cards influence the Papous system, what was displayed and what story was narrated back to the audience [1])

Some tangible user interfaces experiment with combining tangibles with augmented reality displays in order to further reinforce the feeling of merging the real world with the virtual story world. By now, augmented reality has its usefulness already proven across many disciplines, and is slowly becoming more recognized as a possible edutainment platform. With this in mind, Magic Story Cubes were created [4]. In this case, the physical artifact was a cube that portrays various different "pages" of a story depending on what face was being displayed. A camera device capturing the object and displaying it, either from a standard monitor or head-mounted device, presents an augmented reality display of the cube with content mapped onto the faces of the cube. The user can manipulate the story by turning the different cube faces towards the camera accordingly.

Increasingly interesting physical artifacts for tangible user interfaces started to be designed and developed. These new artifacts provide various portions of a narrative depending on how the user interacts with them. An example of a more recent and innovative design are "memory chipped" objects in the Every Object Tells a Story tangible system [6]. Although called "memory chipped" objects, they are actually RFID marked objects which can be scanned by a typical bar code reading device. To provide a futuristic illusion and augment the story world into reality, various objects were marked and fake, shiny and seemingly futuristic "chips" were attached to them.

Figure 3. Various objects were RFID marked, and can be scanned by a bar code reader to display a scene of the story (Using the Every Object Tells a Story "memory chipped" devices [6])

By scanning the objects, users viewed stories from a monitor that portray a story from the perspective of the object in question, as if a bystander to the narrative. By playing and replaying the scenes from the various objects, the users must solve a crime mystery by piecing together the scenes and clues within each one.

Another interesting physical artifact that was utilized for a tangible storytelling interface were the storytelling genieBottles [5]. "*By applying a tangible interface to the field of interactive narratives, we could provide stories with a means of escaping from the computer box and into our physical environment*". Under this theory, the genieBottles, a set of three glass "genie containing bottles" were created.

Each of the different bottles contained a separate genie entity with their very own personalities, voices and stories. The opening and closing the bottle caps were being detected by the system, and will prompt a state change to the system; When individual bottles were opened, a genie was released, narrating its background story and revealing

its personality. Combinations of opened bottles prompted conversations between the genies and further details to the story of how the genies came to be.

The stories were delivered strictly through audio and without a monitor display to mask the technological base of the system and provide it with a more magical aesthetic.

FINDINGS AND PROBLEMS

Despite the previously delivered examples, each one still suffers from noticeable shortcomings which severely hinder each TUI. Most of these design flaws can be traced back to the physical artifact or partially due to the method in which users used the tangibles to interact with the story. This leads to less than optimal delivery of the narrative, often times detaching the users from the story for extended periods of time until the complication was resolved or ignored.

The core influencing factor for the concept and development of the card based TUI systems, such as the Story Builder or Papous [1], was the target audience. Both interactive stories were aimed at children at around the age of five years old. The reasoning behind choosing a card based system was so that the interaction would be simple enough for children to pick up and know how to use instantly. However, this main feature turned to backfire, especially for the Story Builder. The cards proved to be too mundane, and the interaction between the cards and the portrayed storyline was not obvious enough for children to immediately comprehend. The result was the children not being engaged with the story at all. A few of the cases went as far as the children deeming the Story Builder as confusing, and hard to use. This was especially apparent in younger children ranging from three to five years old[1].

Papous on the other hand, succeeded where the Story Builder failed, managing to engage the children as they interacted with the old virtual grandfather narrator within the system [1]. However, this was more due to the display of the Papous avatar and the delivery of the story through sound and the monitor display. The card interactions resulted in becoming bottlenecks to the system that would have worked fine without them, creating unnecessary pauses and blank time when the children were trying to learn to use the system.

Another TUI which was not very effective was the Magic Story Cube and other augmented reality cube systems [4]. While the interactions with the cube artifact were potentially more dynamic than that with cards and slots, the system still fell short in interactivity. Users were essentially turning the pages of a book when using the cube. The storyline, while interesting, was still strictly linear, with the tangible becoming a gimmick which was also hard to develop and setup, due to the requirements of a camera and computer system with software capable of augmented reality.

Figure 4. While the interactions were potentially dynamic, it was essentially still linear (Example of an augmented reality cube telling a story [4])

For the object stories told with the RFID "memory chipped" artifacts in Every Object Tells a Story [6], the interactions proved to be much more successful than the previously mentioned examples. Over the course of approximately a year, test subjects for this system seemed to grasp the system almost immediately with little training. The exploration of the storyline was dynamic enough to keep users interested and scanning subsequent objects to reveal more about the narrative. However, subjects referred a distinct similarity between this system and playing through a set of cassette tapes with a machine. And due to the small number of "memory fragments", the story was also lost upon some of the test users, with mentions of the storyline being convoluted. The system was also bound to an RFID scanner device, which some said broke the flow of the narrative due to failed detections of the bar codes.

The genieBottles [5] stand out above the rest of the examples as the one TUI which succeeded in delivering its stories almost flawlessly. The illusion created by the bottles and audio delivery of the narrative by the three genies created interesting dynamics and interactions between what story was told and which bottles were opened. The creators also hinted upon possible educational use of the bottles, perhaps having users create their own stories and placing them within a genieBottle. While successfully creating a bridge between the virtual genie stories and the physical realm, the physical artifacts and the possible interactions a user can perform were limited to the opening and closing of each bottle.

MORE RECENT EXAMPLES AND POSSIBLE SOLUTIONS

Advancements in tangible user interfaces were made in the past, but one prominent flaw in every past design was the physical interactions that a user was able to perform. The genieBottle system [5] especially details this phenomenon. Despite becoming a widely known success in tangible interface design, the physical interactions were still limiting

factors to the system as a whole. The possibilities of combining physical interactions with a virtual story world and making those physical interactions meaningful has yet to be fully explored. Only a few rare examples exist currently that break the trends of previous tangible user interfaces and attempt to engage users with both interesting story and immersive and meaningful interactions.

Taking note of previous works such as Every Object Tells a Story [6] and genieBottles [5] and paying special attention towards their flaws and shortcomings, the Reading Glove [3] TUI was created. This system takes inspiration from many cultural and fictional endeavors towards the concept of psychometry, also known as "object reading". The Reading Glove enables users to be able to interact with similarly RFID tagged objects like those from previous tangible user interfaces, the exception being the method of which users perform these interactions. In order to read the memories of an object, users must first equip themselves with a glove device capable of reading RFID tags.

The glove in question is ingeniously designed. In order to retain a hands-on experience, the user must be able to move freely, unencumbered by the device. The system must be able to allow the users to handle the objects physically at all times, able to fiddle with the objects while extracting memories without fear of breaking the flow of the narrative. Users must also be able to use both their hands without being held back by cables or other components of the device. Everything must be hidden and still provide the functionality required.

With the above points in mind, the glove was designed to be as unobtrusive as possible. Tactile experience was reinforced by finger holes in the gloves which allowed the users to actually touch the objects. The gloves also provide adjustable straps to accommodate hands of every shape and size. The RFID detector was outfitted on the palm of the gloves, and to avoid obstructive cables, the devices' power supply was fitted within the back of the glove within a small pocket compartment, adding slight extra weight but not hindering any possible interactions with the object, which were kept strictly to the palm-side of the fingerless glove.

Despite the system as a whole working very similarly to Every Object Tells a Story [6], the Reading Glove proved to be much more effective than its predecessor [3]. Instead of trying to camouflage the physical artifacts the user was interacting with, a device tailored to this tangible user experience was developed as opposed to using an ordinary bar code scanner. The physical interactivity and narrative experience was supported by every small detail that helped making the end experience as smooth as possible, right down to the finger holes and adjustable straps in the gloves.

Figure 5. The Reading Glove is ingeniously designed in order to retain a hands-on experience (Picture of a Reading Glove and the hidden components within them [3])

Another separate branch of tangible interface evolved towards the use of puppets for interactivity. Not only are these very familiar to adults and children alike, but it also provides a platform with which interactive stories can be told. The nature of puppets also hints at possibilities of users constructing fresh new stories dynamically.

The iTheater Puppets [2] were modeled after the hand puppet theatres prevalent throughout multiple cultures. Being extremely potent interfaces for imagination already, the hand puppets were augmented with a computer system by attaching sensors such as RFID tags and accelerometers to various parts of each puppet. As the user moves the puppets, the TUI detects these movements and attempts to translate them to actions for virtual actors within the computer system. These range from walking, sitting and jumping. These interactions could also be used to interact with objects within the virtual environment, thus progressing the story in whatever direction the user pleases.

Another example of a TUI that utilizes puppets is SenToy [1]. As opposed to iTheater hand puppets, the puppets utilized for SenToy are a set of larger puppets designed for a younger audience. These puppets are similarly outfitted with sensors and detectors for tracking the movements of the puppets. Relative distances between each of the sensors were used to calculate the "stance" of the puppets, which corresponded to the emotions of the puppets. The use of SenToy as a channel for emotional expression opens up very interesting dynamics for constructed storylines, as well as immersive interactions with the narratives that were provided to the children using this system. This interaction proved to be even more successful when the SenToy components were utilized to control the progressions of the previously mentioned FearNot! storyline [1], where the protagonist must consolidate with a bully victim.

Figure 7. The use of SenToy opens up very interesting dynamics as a channel for emotional expression (A group of children using SenToy to portray emotional states [1], notice the stance of the puppet and the actor both corresponding to sadness)

SUMMARY

In conclusion, we have examined and provided an overview of the evolution of interactive storytelling and how it has recently started to incorporate itself with tangible user interfaces.

By using tangible interfaces, interactive narratives were able to be more engaging and immersive due to the nature and physicality of using physical artifacts to interact with storyline. However, the tangible must be meaningful to the story in order to provide an impact, as well as not being obstructive to the narrative procedure.

Past examples, such as the Story Builder [1] and Magic Story Cube [4] portray tangible user interfaces that succeed in becoming interactive mediums, but fail at the degree of interactivity provided by the system, either falling short in the narrative, physical artifacts or combinations of both. Other examples, such as the memory objects in Every Object Tells a Story [6] and genieBottles [5] provide deep and meaningful narratives, but the tangible interface with which users interact with the system becomes more of a liability and hindrance to the delivery of the story, rather than increasing immersion or aiding the storytelling experience.

It is clear that a fine balance is required between the physical interactivity and the dynamic narrative structure for tangible story interfaces to succeed. However, the key to developing a true interactive narrative experience is the actual tangibles themselves; They must not hinder the user's interaction with the story whatsoever. Examples such as SenToy [1] and the Reading Glove [3] show that once the tangible device becomes second nature to the users, providing an unobtrusive link between the user and the storyline, true immersion can be achieved, resulting in higher levels of emotional impact, educational and entertainment value.

FUTURE WORK

Despite major evolutionary steps taken by interactive storytelling and augmenting them with physical interactivity, technological advancements in the area of tangible devices seem to fall short. Many tangible user interfaces still support themselves on dated concepts such as cards and slots, augmented reality cubes and other familiar yet mundane devices.

New and innovative devices with which to interface users with the interactive narratives must be developed to bridge this gap. The Reading Glove [3] is a very prominent example of this. It also exhibits how crucial it is for these devices to be fine tuned to perfection in order to make user experience as smooth as possible. A separating factor between the puppet based interfaces [1][2] and the Reading Glove was the fact that the puppets were not able to be interacted with as smoothly as the gloves. The gloves were extensions of the user's hands, whilst the puppets could potentially be awkward to use and exhibit detection problems, resulting in slower and more accented movements to be used in order for the system to function.

genieBottles are also an example of how simplicity in usage technique could aid a tangible interface, with only sound to deliver the narrative and the bottle caps for interaction. Although considered a limiting factor, this interface's simplicity may also be the cause of its success.

Future tangible user interfaces should be simple to use, intuitive to pick up and not obstruct users to their end goal of interacting with a storytelling experience.

Figure 8. Although considered a limiting factor, simplicity may also be the cause of its success (Picture of the genieBottles with caps open [5])

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