Augmenting Tangible Interactions for Storytelling

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ABSTRACT
Narration forms an important aspect of life. Till date, we remember the stories that were narrated to us as we grew up. Stories form a postern to connect our imagination to the real world. Storytelling comes in handy in various aspects of everyday life, be it developing corporate strategies, for entertainment purposes, teaching children, etc. Most children have a penchant for stories. This is the reason that the teaching fraternity employs storytelling in educating young children. Imagine a scenario where children could view, hear and manipulate the story characters. It is a well-known fact that we learn easily with audio-visual aids. To virtualize the story characters we need a platform that forms a link between physical artifacts and digital technology, this is where tangible user interface (TUI) comes into play. This report is a functional study of all the existing interactive storytelling prototypes. The components that form an interactive storytelling system are elucidated in this report. The methodologies these systems employ along with problems and sub-problems associated are discussed in detail. Interactive storytelling prototypes aim to provide a natural environment to users which would preserve the traditional storytelling experience. The narrative environment generated however, have certain shortcomings which have been highlighted in this report.

Author Keywords
Tangible User Interface (TUI); Radio Frequency Identification (RFID); Infrared (IR); Light dependent resistors (LDR); Storytelling;

ACM Classification Keywords
H.5.2 **[Information Interfaces and Presentation]**: User Interfaces.

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General Terms
Prototypes, Narration.

INTRODUCTION
Stories have always been a part of every individual's life. We grow up learning several attributes from different stories; the most important lesson learnt is the difference between good and bad, they teach us how good always wins against the evil. There are numerous other qualities and aspects of life that we adopt from these stories which were narrated to us as children. The lessons taught to us through narration are still fresh in our memories; this is because the whole storytelling concept is entertaining. This concept of education via storytelling still remains popular with educators who teach young children. Storytelling consists of narration of events with the help of external aids like text, sound, picture etc. The importance of storytelling in designing new technology is discussed by the author in [4]. It is stated that a story makes designing convenient as it allows the designers to relate a user's experience and implement new designs as desired. Storytelling is also used as a primary tool by corporates to manage business proceedings [5].Technology helps enhance the storytelling experience by adding a virtual component to it. Authors in many studies [1, 3] have created interactive tools that focus on narrative evolution for young children. These platforms assist in co-existence of the traditional storytelling methodologies and digital media. Imagine virtualizing a story by bringing the objects, characters and scenes associated with it to life. It is a human tendency to understand things with ease by audio and video elements, rather than just textual information. Virtualizing the external articles linked to a story is possible by Tangible user interface (TUI). Objects add a whole new dimension in storytelling. This has been implemented by the use of props for narration, which makes the stories captivating and helps to maintain the user's focus.

This report will discuss the prototypes created and technologies employed for interactive storytelling. The psychological aspects involved, like choosing external entities as tangible interfaces will be analyzed; along with numerous sensors and hardware that allow a child to mirror his imagination to the real world.

COMPONENTS OF STORYTELLING PROTOTYPES
Several features cumulatively produce a storytelling system. The components include objects, tangible user interfaces (TUI), numerous sensors involved in converting imaginary characters to virtual characters, etc. In this section we will briefly discuss all the major components of interactive storytelling models.

Psychological aspects of objects in Storytelling

Objects form an efficient way of expressing one's thoughts. Individuals make use of external entities to exchange views across various communal and traditional boundaries. As stated by the authors of [6], people, especially children make use of personal belongings and articles to build descriptions from their imagination. External articles allow people from different cultural groups to communicate with each other on the same wavelength.

Objects also form a good mode of entertainment. Numerous interactive storytelling prototypes [1], [3] are designed for the purpose of educating young children. They state that children can associate themselves easily with objects that assist them in creating stories. In both of the prototypes developed by the authors of [1] and [3], objects are not only used for their physical significance; but are also used as a gateway to an individual's imagination. The author of [7] states that a research in psychology has proved the usefulness of computers in collaborative activities for children. The figure below (Figure 1) shows the use of external objects in interactive storytelling.

Figure 1. Children using props while enacting a story [7]

Objects help us to bridge the gap between the present and the past. Apart from adding the entertainment component to stories, objects also add flexibility in gathering the entire expressive gestures and other non-verbal [1] attributes; that otherwise would not have been captured. Ken Newman in [8] states that humans understand better with the help of narration. It is stated that narration forms a basic element in a child's learning process. In the work done by author in [3], it is explicitly mentioned that young children create stories by portraying the objects as various characters. It is stated that narration triggers the initiative in a child to take control of the objects and incorporate them in their narrative experience.

Objects add another perspective to the narrative experience. It is the presence of external entities that form the main functional unit of narrative in such stories [2]. Stories that are narrated by the employment of external objects have the probability to trigger scenarios that otherwise remain unexplored by old-fashioned storytelling methodologies.

Tangible User Interface (TUI)

Tangible user interface is a vital part of storytelling prototypes. As discussed in the previous section, interactive storytelling systems allows children to put life into their imaginary characters; this is possible with the use of TUI's. Tangible user interface makes it possible to interact with digital media via physical objects.

Graphical user interface (GUI) is the ordinary archetype for interacting with computers. These interactions are operated with the use of generic controllers, for example a mouse or a keyboard. Using GUI's we can graphically access vast amounts of digital information. However, it does not permit us to apply our skillset completely by manipulating external entities. The shift from GUI to TUI was somewhere in 1990's, this move was initiated by a group at MIT [9].TUI's incorporate the physical aspects of the user environment with digital media. TUI assists us to alter digital information with our exterior senses. TUI's evolved over two generations which were Urban Planning Workbench (URP) and SandScape [9]. The details of these two phases of TUI are omitted as it is beyond the scope of this report. The figure below (Figure 2) depicts how a physical object, in this case a cubical model is converted to a digital representation of a shadow.

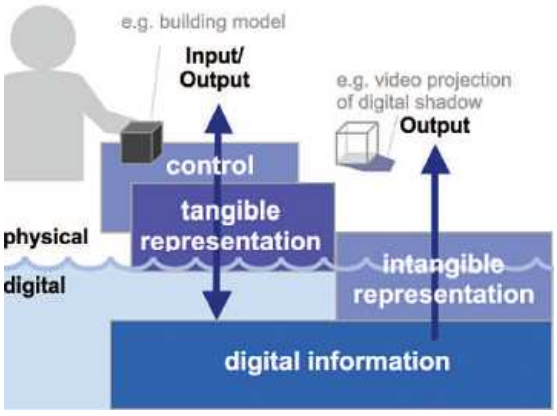

Figure 2. Conversion of physical entity to digital image [9]

TUI takes human computer interaction to a whole new level. TUI does not require technical expertise and users without technical background can easily interact via such interfaces. For instance, the author in [1] describes iTheater. It generates an environment that allows young children to create or reconstruct stories by virtualizing the story characters. The prop that the author uses is a hand puppet. It is argued that the use of hand puppets as tangible interface provides children with an interactive platform to depict their stories. Another example of TUI is described in the work done on PageCraft [3]. Like any other existing model employed for storytelling, the prototype's goal is to narrow down the gap between the physical environment and digital technology. The TUI deployed allows children to generate

stories with complete functional control. There are several similar prototypes that would be discussed further in this report.

Hiroshi [9] states that the aim of TUI's is to enable cooperative learning through technology by manipulating physical artifacts. The goal of all the prototypes developed is to provide users with a TUI that would make the use of technology relatively easy.

System Implementation

Interactive storytelling systems employ various sensors and respective readers to tag physical objects with computers. Interactive storytelling systems embed the artifacts with such sensors that allow them to be identified uniquely. Different sensing technologies can be employed to tag the objects. One such technique is Radio Frequency Identification (RFID). RFID uses the radio frequency to transfer information from an object tagged with it. RFID reader relays back the information from the tagged object to a computer which supports an environment that permits modeling of audio-visual interaction. Figure below (Figure 3) depicts the functioning of an RFID sensor.

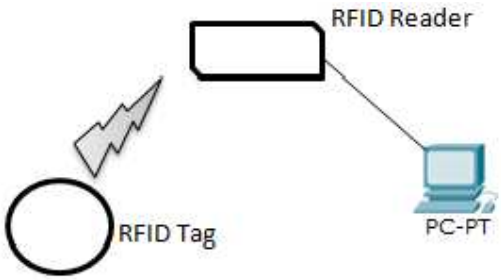

Figure 3. A diagrammatic representation depicting the functioning of a RFID sensor.

As stated earlier, different technologies can be employed to interface physical artifacts with digital media. The author in [1] used infra-red (IR) light emitting diodes (LEDs) to track the arm movements of the hand puppet which was used as a TUI by the author. Whereas, the author in [10] used the photographs of objects and integrates them with the narrative. All the various hardware and software used in interactive systems have a common purpose, i.e., to link the physical media with digital media. The choice of technology used may differ in different prototypes, depending on the purpose that a particular model is trying to solve. Irrespective of the sensor technologies employed, all the prototypes aim to provide maximum flexibility to the user in terms of story narration and creation. Hardware used should not hinder the narration process. An interactive model should not incorporate complex technologies which complicates the usage.

PROTOTYPES DEVELOPED

We would now discuss the existing interactive storytelling models. As stated in the previous section, each prototype aims to provide a user friendly environment that takes narration to a whole new level. It is not always possible to create a system that is problem free. This section will discuss all the features and problems associated with the existing prototypes, followed by a comparative analysis.

PageCraft [3]

Like any other storytelling prototype, PageCraft aims to provide an interactive environment for narrative development of children. It allows the user to generate stories with complete control of the narrative environment. At the end of the narration, it enables the user to keep the hardcopies of their narrative.

PageCraft comprises of few printed stories, blocks and characters to depict the narration and a laptop which has compatible playmats. The blocks used in stories are tagged and detected by the collective action of the IR sensors and light dependent resistors (LDR). The manipulation of the blocks on a playsurface which houses these sensors results in creation of a scene from a database of predefined pictures.

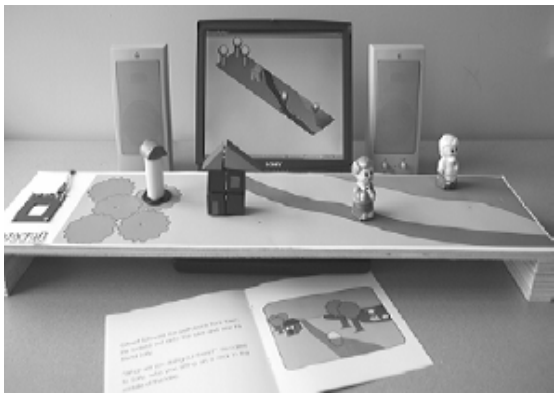

Figure 4. Setup of PageCraft [3]

One drawback that we can infer is the limitation of space. The sensors are deployed on playmats which would restrict the child to narrate or create the story in a limited space. Secondly, the scene is created with the help of predefined images; this implies that same images will be repeated for difference story scenes.

iTheater[1]

iTheater is an interactive storytelling system. The goal of this model is to create an environment for children which would allow them to virtualize their imaginative powers. The author used hand puppets as a tangible interface for interaction. In his design, he has tried to relate it closely to the traditional puppet theater.

The iTheater comprises of a puppet interface, which is used to manipulate the virtual characters and a TUI toolkit that assists in animation of virtual characters through physical artifacts. Infra-red (IR) vision system was employed for the implementation of the puppet interface. IR system tracked the vertical movements of the hand puppet. The RFID tags

were used to transmit information from the physical objects, in this case; the hand puppets to the computer. The system permitted children to choose their own fictional figures, it had the facility of audio-video editing, and kids could change the background of the narrated scene, etc.

Like all compound systems, iTheater had certain drawbacks associated with it. Before the development of the iTheater, few users had experienced Nintendo-Wii, which they reported was similar to iTheater. Secondly, many users found iTheater difficult to use.

Figure 5. Components of iTheater [1]

In order to be recognized by the sensors, the puppets had to be moved slowly. This restricted the natural flow of the narration. Also people using two puppets at the same time found it difficult to manipulate other objects associated with the story. The figure (Figure 5) portrays the functional components of the iTheater system. After closely analyzing the components, it can be inferred that if two puppets are used simultaneously, it would indeed restrict the user movement.

The Reading Glove [2]

The Reading Glove (Figure 6) is a TUI that was modeled on the concept of semantic characteristics of tangible interfaces. This prototype uses the concept of interacting with the external entities with the help of RFID sensors. The purpose of the designed prototype was to create an interactive storytelling system that would interface digital technology with physical artifacts providing a natural environment to the users.

The prototype devised required the external entities to be held using the glove. Each object had a unique piece of narration associated to it, the narrative contained information in textual or audio format. The collective permutation of all the artifacts used would result in a single story narrated by the objects. The external objects used were tagged with RFID sensing technology. To simulate a natural environment the author wanted the system to be free of wires. This was achieved by the employment of a portable RFID reader. The information from the tagged objects was conveyed to a system that supported manipulation of audio and video interactions.

The tagged object when held narrated the part of story associated with it. The problem with this was that when the person holding the object moved or turned it while narration, it triggered multiple activations of the same tag. This replayed the audio linked to that particular object. To solve this issue, the author configured the tag to only be activated once. This was an apt solution of the problem. But this instead gave rise to a new drawback. If the person interacting with the object wanted to replay the audio track he would first have to hold some other object with different tag and then return to the first tag. Secondly, the aim of the Reading Glove was to make the interaction with the objects in a natural environment. The RFID tags were clearly visual on the objects. When the author tried to rectify this, it did not work as passive RFID tags are based on principle of induction. The operative range of such tags drops significantly if they are placed near metal objects. This did not allow the tags to be completely hidden in the objects. Another issue that the author came across during the pilot study was that if a second object was touched during the narration of the previous article, a new event would be activated which would interrupt the current playing narrative. The event triggered resulted in the narration of the second object. This forced the users to wait for the current narration to end before investigating other objects. This did not allow users to interact with the system naturally as the author intended.

Figure 6. The Reading Glove [2]

TellTable [10]

TellTable is a storytelling prototype which was designed for collaborative activities among children. TellTable differs from the prototypes discussed previously by the fact that it allows users to create stories by using photos of physical objects and the images drawn by the user. In previous storytelling models discussed [1, 2] the user had to hold the object at all times during the narration. TellTable was made compatible to function on a multi-touch environment. It

permitted kids not only to incorporate physical objects in the stories but also allowed them to be the characters of the narrative. It made it possible for any physical object to be employed in a story.

TellTable was designed to eliminate the use of external props for navigating through the story. The objects were physically used before the narration started. A photograph was taken of the objects to turn them into characters. The photograph could be cut in any shape as desired. After that all the manipulation of objects was directly via a multi-touch surface. It comprised of two modes. The *Make mode* permitted children to create stories and the *Tell mode* permitted narration of stories.

Figure 7. Children taking photographs of the objects [10]

One major drawback of TellTable is that it confines the space of interaction just till the table. Other storytelling systems like the Reading Glove [2] allowed the user to move freely with the artifact. Also, giving shapes to photographs went wrong if many people touched the interface. This according to me hinders collaborative learning.

Reactoon [11]

Reactoon was designed to provide a platform where users could create and edit their own narrative without dealing with the complexity of the system. It offers collaborative learning by means of a tangible interface and a multi-touch environment. The system contains a repository of digital images that are associated with respective physical artifacts. The narrative comprises of rectangular fragments that allow users to create or edit a story.

The users are provided with a pack of cards with the pictures depicting the narrative. When these cards are placed on the surface of the table the scene is recorded by the system. The users can choose the characters and the objects with their position from a predefined set. This prototype allows creation of narrative, it allows the users to save or delete the story they created and users can also record a voice clip they wish to associate with the story.

Since Reactoon is an initial prototype, the pilot study was not conducted. It can be inferred that Reactoon puts constraint on narration as it is confined to the table top. Also the characters used are linked with the predefined images from the library. This implies not every object can be used for narration. Hence, the users will have to choose form a set of predetermined objects

Voodoo [12]

Voodoo is a work in progress which aims to achieve virtual interaction with dolls employed as tangible interface. It allows children to animate characters; the animation is based on the description of a popular predefined story. For narration to be successful, a child must know the relative information about the character. This will result in object virtualization according to the anticipated narrative.

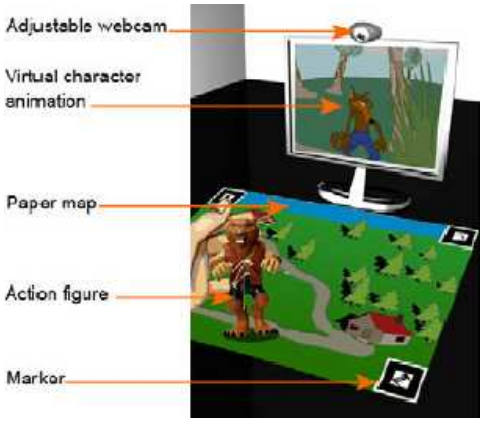

Figure 8. Voodoo system [11]

The prototype (Figure 8) is equipped with a paper map which contains markers that triggers the narrative. It works by simultaneous operation of computer vision, based on a *color blob* tracking of objects and the markers that trigger a narrative event.

The results of pilot study are not provided in the literature but after reading the description of the prototype, the first drawback that can be inferred is that it does not allow children to create their own story. The story is based on the dolls or action figures that are used as tangible interface. Secondly, there is no facility that allows children to edit the story. An interactive storytelling system should not restrict the scope of narration. Voodoo does not incorporate the natural aspects of traditional storytelling.

Prototype	Interface Employed	Technology Used	Limitation	Multi-touch	Audio and Video	Recording Animations
PageCraft [3]	Play Blocks	IR sensors and LDR	Interaction limited to playmats	X		
iTheater [1]	Puppet Interface	IR system and RFID	Lag in object recognition	X		
The Reading Glove [2]	Glove	RFID	Replay required object switching	X		X
TellTable[10]	Table	Microsoft Surface [13]	System malfunctioned in multi-user environment			
Reactoon [11]	Table	TUIO Protocol	Limited narration			
Voodoo [12]	Dolls	Color Blob Tracking	Narration is predefined. No room for story editing.	X		X

Table 1. Comparison of prototypes discussed in this report.

The table (Table 1) gives a comparison of the prototypes discussed in this report. All the storytelling prototypes may differ in the implication but their motive remains the same, i.e., to provide a user-friendly tangible interaction for narrative purposes in a natural environment

CONCLUSION & FUTURE WORK

Every object narrates a story; the difference lies in the manner in which we perceive it. Tangible User Interface provides an effective way to link the physical artifacts with digital technology. Interactive storytelling not only makes the story interesting but also forms an effective methodology to educate young children.

In this report we briefly studied few existing interactive storytelling prototypes. We observed that these various models incorporate a range of technologies that introduce a component of entertainment in education. Although the storytelling models discussed provide an effective way to link the objects with technology, each has its own limitation. Interaction via tangible interfaces started in mid 90s and is a work in progress. The author in [14] is developing an interactive storytelling model in which a branch will narrate a story depending on the location of user's hand producing a shadow animation. Another work in progress is TOK [15] which allows pre-school children to create stories with help of a book shaped prototype and a pack of cards.

In conclusion, narration through tangible interaction provides an apt environment for young children to learn. Interactive storytelling enables one to bring imagination to life. Every object tells a story and interactive storytelling systems form a medium for the object to narrate its story.

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