RoboStory: A Tabletop Mixed Reality Framework for Children's Role Play Storytelling

Haipeng Mi
University of Tokyo
7-3-1 Hongo, Bunkyo-Ku
113-8656 Tokyo Japan
+81-3-5841-6394
mi@itl.t.u-tokyo.ac.jp

Aleksander Krzywinski
University of Bergen
Fosswinckelsgate 6
5007 Bergen Norway
+47 982 68 173
aleksander.krzywinski
@infomedia.uib.no

Masanori Sugimoto
University of Tokyo
7-3-1 Hongo, Bunkyo-Ku
113-8656 Tokyo Japan
+81- 3-5841-6796
sugi@itl.t.u-tokyo.ac.jp

Weiqin Chen
University of Bergen
Fosswinckelsgate 6
5007 Bergen Norway
+47 55584143
weiqin.chen
@infomedia.uib.no

ABSTRACT
In this paper, we present RoboStory, a mixed reality tabletop storytelling supporting system which enables children to create and present their own story in collaboration. A robot which can interact with characters, items and other children is used to enhance story presentation.

Categories and Subject Descriptors
H.5.2 [INFORMATION INTERFACES AND PRESENTATION (e.g., HCI)]: User Interfaces - Interaction styles, Prototyping User-centered design

General Terms
Design, Human Factors.

Keywords
Storytelling, Role-play, Children, Robot, Tabletop, Tangible.

INTRODUCTION

Storytelling is one of the teaching methods used in primary education that encourage children's collaboration to create and present stories. Storytelling can develop various skills of young children such as linguistic skills, social communication, logical thinking and even imagination [14]. In Japanese elementary school classes, students are asked to play a specific role in a given story and read their words out loud [9]. Such storytelling activities are effective for getting involved in the story, empathizing with the different roles, understanding the scene of the story, and developing children's capabilities. Moreover, if children can create their own story and present it visually, it can be more effective for enhancing children's creativity and imagination [8]. Therefore, we propose RoboStory, an interactive tabletop storytelling system based on the RoboTable framework [10].

The RoboTable framework (Figure 1.) combines several technologies and forms a basis on which multi-touch applications with tangible objects and robots can be created. Through the integration of open source frameworks like MT4J, ReacTIVision and JBox 2D, it is a potent platform for rapid application development.

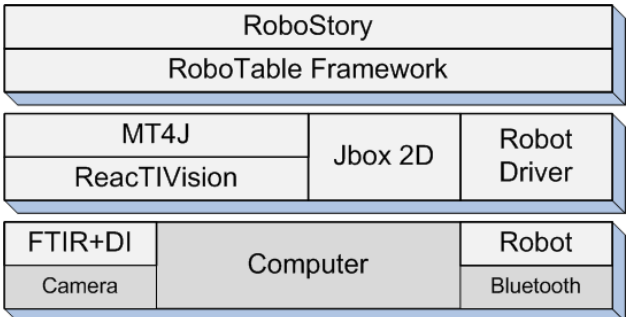

Figure 1: RoboTable architecture

RoboStory creates a mixed reality, tabletop environment for children where they can create an original story, design the story script and present it with the aid of the robot. RoboStory is currently under development, and this paper outlines the main proposed features and the current state of the system.

RELATED WORK

Interactive storytelling systems can be divided into two following categories: Desktop-based storytelling support systems and Physical-space-based storytelling support systems [5].

KidPad [7], and JabberStamp [11] are examples of desktop-based storytelling support systems. A typical feature of these systems is that children create and present the story in a virtual world. More recently, tabletop interaction technologies are used to enhance such desktop-based storytelling support systems. TellTable [2] uses a multi-touch table where children can draw story scenes and characters directly with their fingers.

Many systems have been proposed to support children's storytelling activities in a physical space. KidsRoom [1], and StoryMat [12] are examples of such physical-space-based storytelling support systems. In such systems, children can interact with other children or artifacts, in an

immersive environment enhanced by mixed-reality technologies. In some of the research, a robot is used to enhance story presentation. In PETS [3], children use a pet robot that displays emotions and behaviors based on their story. Gentoro [13] uses a robot and handheld projectors so that children can dynamically guide the robot to present the story like producing a film.

RoboStory leverages the strong points of both desktop-based and physical-space-based storytelling support system. It provides a mixed reality environment in which children can use both virtual and real objects to create and tell their story.

ROBOSTORY

Overview

With RoboStory we aim to aid children's collaborative story creation and presentation in a tabletop mixed reality environment, and to achieve these aims our prototype is designed with the following features:

- Multi-touch, multi-user drawing on tabletop, which encourages children to collaborate when creating scenes, characters and items.
- Enable children to use everyday items as props in the story, which provides children a natural way for story creation
- Using a robot as the protagonist and allowing children to play different roles in story presentation
- A wireless camera mounted on the robot to capture live video from the perspective of the robot providing children with a first-person view of their story.

Multi-touch, Multi-user Drawing

Drawing is one of the most ancient communication techniques. To let children express through drawing is an important factor in their storytelling [4]. According to [13], children prefer to use crayons and paper for drawing rather than drawing with a mouse on a computer. Most computer aided drawing tools does not allow multiple users to simultaneously draw on a drawing canvas, or for several drawings to be drawn in parallel. However, some later research shows the possibility of using a multi-touch tabletop system to support children's drawing [2].

In order to provide a better collaborative environment for story creation, we propose a multi-touch, multi-user drawing canvas, allowing children to draw the elements in their story directly at the table using their fingers. The governance of the drawing is supposed to be as free form as possible, so as not to limit the children's creativity, but the system must be able to separate different drawings, and their internal state (e.g. the current color or stroke size) must be preserved as not to create confusion.

To achieve this we propose to use tangible objects, each representing a sub-canvas with its own internal state. The actions within this sub-canvas are completely disjoint from the other canvases, and the tangible will act as a memento for the children to help them separating the different drawing contexts. The system will remember the drawing created on a canvas, even if the tangible is removed from the table for a long time, enabling the children to continue drawing at a later moment if something else catches their immediate attention.

Children can draw different kinds of elements such as the background scene, characters, locations or items to be used in the story. They can also rotate, drag or zoom their drawing freely using standard gestures. Every element created by this drawing system can easily be included in the story and used for the children's story presentation.

Using Everyday Items

In traditional storytelling processes, children will affectionately use toys or puppets to improvise a story. These toys act as important catalysts of the story, and can spark the children's creativity. Thus we argue that using everyday items that children are familiar with will aid children in both story creation and presentation in RoboStory.

By pasting one of the special fiducial markers recognized by the tracking software on the bottom of their own items, the children can use the item as a part of their story. The system will subsequently track the marker's position and orientation on the table surface, thus allowing for interaction between the real object and virtual objects or drawings.

A drawing canvas attached to the object will also be available, enabling children to easily extend the meaning of their own toys or puppets by adding drawings. The virtual drawing will be attached to the physical item, always follow the position and direction of the item, or temporarily disappear if the item is removed from the table.

This will enable children to effortlessly incorporate their toys or puppets in the story, as locations or characters the protagonist must travel to and interact with, or as focal points of attention and story progression.

Using a Robot as the Protagonist

As one of our design goals is to allow more than one child to be involved in story presentation, we propose to allow children play different roles in the story. The role can be manifest by a puppet, a virtual drawn character, themselves etc. The children are all supporting cast to the robot, which is the protagonist in the story, and the key issue is to allow the children as much creative freedom as possible.

The robot, as the silent hero of the story, will move to, and interact with, different characters, items and locations as the story is played out. The actions of the robot are paced by the children's actions (e.g. by placing marked objects on the table, dragging virtual items to the robot etc), their expressions (by facial recognition) and the flow of the storyline. The children can explain the robot's actions, and thus the story is told collaboratively as the storyline progress.

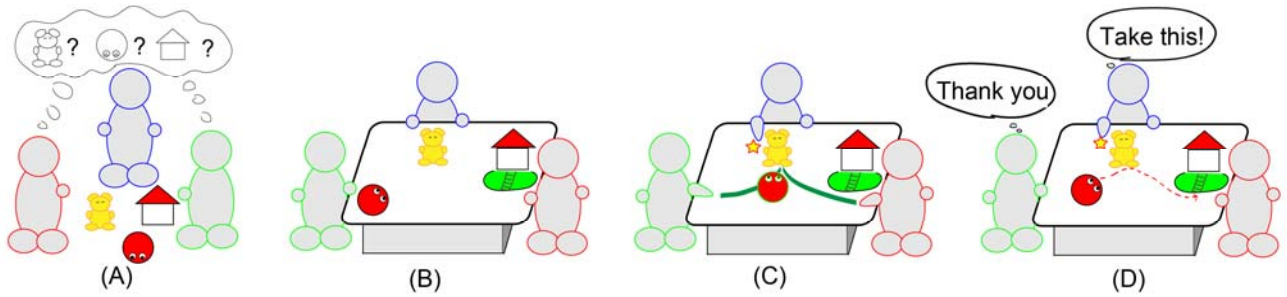

Figure 2: A) Story planning, B) Stage creation, C) Script development and D) Story presentation

In RoboStory, the robot has two main activities: move to a certain place and interact with a character or an item. To make the robot control simple enough for children, we propose an intuitive human-robot interaction (HRI) method in which the children can directly define the start location and end location of a movement and the robot will automatically find a path between the two points.

This simple manipulation method allows the children to concentrate on story design and creation. The robot does not store the position of the location, but rather a reference to the location element in memory, so that it can find its way to the location, even if the location subsequently has been moved (e.g. a child has taken a toy and placed it elsewhere on the table).

Once at a location, the robot can be instructed to deliver an item in its possession, or to retrieve an item present at the location. This is easily instructed by the children using simple point-and-touch gestures.

The wireless camera

The robot has a camera mounted facing in the forward direction. The video stream from this camera is used for two purposes: To show the story from the robot's perspective, and to enable the system to recognize the faces of children around the table.

The first-person view shows the objects on the table, both real and virtual, as seen from the robot, as well as the children along the table edges. This view can be presented on a separate screen, and thus augment the children's storytelling with a visualization of the robot's perspective. The virtual objects will be rendered as standing circles in a three dimensional space, using the children's drawings as textures.

Using facial recognition, the robot can navigate to a specific child that plays a role at the current point in the story. Once there, the child must interact with the robot, and, if desired, tell a little part of the story, before the robot continues its journey.

STORY STRUCTURE

In order to support interactive story creation and presentation, several essential elements are needed. In our story structure, we use some well defined story components that together form a script to control the story. Figure 2 shows an overview of the story creation and presentation process.

Story Components

Characters: Children can create different characters for the story. They can use either a physical puppet or a virtual drawing to be a character. The robot is a special character, the protagonist. It travels around the table and interact with other characters.

Children need to create their own characters, and play the role of their characters collaboratively while expressing the story. To some extent, the children are also characters.

Locations: A location is a place on the table which can be set as a destination for the robot. The location can be assigned to either a virtual drawing, a real item such as a puppet or one of the children. The location is then used to define the robot's path.

Items: An item is a virtual object that can be carried or picked up by the robot, or delivered by a character. Items are not a necessary factor for all stories, but the possibility to express details in the story with items will enable the children to be more imaginative.

Actions: There are two kinds of actions in RoboStory: movement and exchange.

A movement action is defined by specifying a destination location. This action will move the robot automatically from current position to the destination location.

An exchange action is defined by specifying an item and whether the robot should pick it up (if it is present at the current location) or deliver it (if the robot is currently carrying the item). To define such an action, a child only needs to drag the corresponding item to a location or the robot, and the system will understand which action should be taken.

The Story Script

The script is a sequential list of actions that represents the story line, and during the presentation it controls how the story is acted by the robot while children are telling it. We propose an easy-to-use and visualized script system.

The actions that the children create on the table will be automatically added to the script, and the script will employ different algorithms to make sure it is always internally consistent.

During the story presentation, the robot will play out the actions in sequence, while the children will explain the context and reasons behind the robot's actions. At chosen points in the story, the children will have to interact with the robot to progress the story, thus enabling the children to pace the script playback to their storytelling effort.

IMPLEMENTATION

We have preliminarily decided to target children at 10-12 years of age, and we want the user interface to be as natural, intuitive and simple as possible for this age group. Further, we also aim for the RoboStory application to be understood by the children, regardless of their mother tongue, thus enabling children from different countries and cultures to create stories. Hence, the user interface relies on simple symbols instead of words, and on the children's own drawings and items instead of culturally dependent iconography.

At the time of writing our prototype implementation allows the users to create (i.e. draw on one or more multi-touch canvases) the virtual locations and items, register the physical objects (toys, puppets), connect the items to their initial locations (both physical and virtual) to set up the stage of the story and create movement and exchange actions for the robot.

Presently our efforts are directed at creating an intuitive and usable script representation and editing widget, to enable the children to easily understand the current state of the story line and to effortlessly edit the flow of their story.

CONCLUDING REMARKS AND FUTURE WORK

In this paper we have presented RoboStory, a proposed table-top application for story creation and presentation by children. We have outlined the four main features of the system: multi-touch, multi-user drawing, the use of children's own toys as props in the story, a robot as the protagonist and the first-person view and facial recognition by a robot mounted camera.

We have also listed the main components a RoboStory is comprised of, and shown how we propose that these components can be composed into a storyline by simple drag and point operations.

Our current implementation allows for the creation of the story stage, and we are presently working on the script creation and visualization phase. In the future we will pursue three main goals:

- Implement all the features of RoboStory as outlined above.
- Perform several user studies to establish if the interface is suitable for the chosen age group and to formatively enhance the usability of the system by evaluating feedback from the children.
- Establish if the use of RoboStory can further the creativity and imagination of the children.

REFERENCES

1. Bobick, A., et al., The KidsRoom: A Perceptually-Based Interactive and Immersive Story Environment, *Presence: Teleoperators and Virtual Environments*, 8, 4, (2006), 367-391.
2. Cao, X., et al., A. Telling the Whole Story: Anticipation, Inspiration and Reputation in a Field Deployment of TellTable, in *Proc. of CSCW2010* (Savannah GA, Feb. 2010), ACM Press, 251-260.
3. Druin, A. et al., Designing PETS: A Personal Electronic Teller of Stories, in *Proc. of CHI'99* (Pittsburgh PA, May 1999), ACM Press, 326-329.
4. Evangelista, C., et al., Interactive Storytelling for Children Education, in *Proc. of VS-Games'09* (Coventry UK, Mar. 2009), IEEE Press, 198-201.
5. Fails, J., et al., Child's Play: A Comparison of Desktop and Physical Interactive Environments, in *Proc. of IDC2005* (Boulder CO, Jun. 2005), ACM Press, 48-55.
6. Han, J. Y. Low-cost multi-touch sensing through frustrated total internal reflection, in *Proc. of UIST2005* (Seattle WA, Oct. 2005), ACM Press, 115-118.
7. Hourcade, J., et al., KidPad: Collaborative Storytelling for Children, in *Proc. of CHI2002* (Minneapolis MN, Apr. 2002), ACM Press, 500-501
8. Ito, T., et al., GENTORO: Design and Evaluation of a System for Supporting Storytelling in Mobile Mixed-Reality Environments, *Journal of Information Processing Society of Japan*, 50, 12, (Dec. 2009) 2819-2830 (in Japanese).
9. Japanese Ministry of Education, National Curriculum Standards (National Language) available at http://www.mext.go.jp/b_menu/shuppan/sonota/990301b/990301d.htm (In Japanese, Retrieved in 2008).
10. Krzywinski, A., et al., RoboTable: A Tabletop Framework for Tangible Interaction with Robots in a Mixed Reality, in *Proc. of ACE2009* (Athens Greece, Oct. 2009) ACM Press, 107-114.
11. Raffle, H., et al., Jabberstamp: Embedding Sound and Voice in Traditional Drawings, *Proc. of IDC2007* (Aalborg Denmark, Jun. 2007), ACM Press, 137-144.
12. Ryokai, K. and Cassel, J. StoryMat: A Play Space for Collaborative Storytelling, in *Proc. of CHI'99 Extended Abstract* (1999), ACM Press, 272-273.
13. Sugimoto, M., et al., GENTORO: A System for Supporting Children's Storytelling using a Handheld Projector and a Robot, In *Proc. of IDC2009* (Como Italy, Jun. 2009), ACM Press, 214-217.
14. Wright, A. *Creating Stories with Children.* Oxford University Press (entire issue).