Kids in Fairytales: Experiential and Interactive Storytelling in Children's Libraries

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Abstract
Mixed Reality (MR) has the potential to improve the quality of users' experience by immersing users in the virtual world, but the limitations of computer vision and 3D graphics techniques have made it difficult to bring up practical applications. In this paper we present a mixed reality application that combines a mixed reality experience and storytelling to motivate young children to engage more in reading. We describe system design from physical space to software implementation and share our findings from 4 years of deployment. Since the first prototype was deployed at a national children's library headquartered in Korea, the accumulated number of young visitors reached 15000 and 20 additional children's libraries have installed the system. Our results demonstrate that mixed reality applications create a pleasant and engaging user experience for young children combined with storytelling.

Author Keywords
mixed reality; virtual storytelling; children's library

ACM Classification Keywords
H.5.1. Information interfaces and presentation (e.g., HCI): Multimedia Information Systems

Introduction

Concern about children's literacy and engaging children in more reading have become critical issues in children's education. Tablets and mature digital publication markets allow preschoolers to read digital books with video, audio, and interaction. Interactive storytelling is a widely adopted and compelling way to capture readers' interest and encourage their creativity, communication, and critical thinking [4]. Despite these efforts and an increasing number of children's literature, we still admit that young readers are mostly motivated by their parents and they are more interested in visual and audio queues in digital books.

There has been considerable interest in digital storytelling with interactive media for use in educating children. Recent work focuses on interactive storytelling in eBooks that implement 2D mixed reality along with storytelling. StoryFaces [9] and PeopleInBooks [2] present interactive storytelling in mobile tablets that synthesize users' images with a 2D virtual world. The participation of readers in StoryFaces empowers young children in a social-emotional narrative, while PeopleInBooks motivates young children and their families to be more active readers.

The concept and promise of storytelling in 3D MR was explored in the early 2000s [1,5,12]. Prior works investigated the possibilities of MR storytelling in diverse applications by confirming that users become more immersed and learn better in the mixed reality world. However, the research was limited to prototypes because computer vision and 3D graphics techniques were not yet developed enough to solve practical problems including real-time performance, the quality of both users' image and virtual scenery.

Figure 1. Kids in Fairytales(deployment screenshot). Two children' images are projected into the virtual world.

Our research was initiated by NLCY (National Library for Children and Young Adults, South Korea), which is in charge of Korean nationwide librarian services. The goal of the research is to motivate young children's reading by providing a virtual experience and linking it to literature. We developed a 3D MR system that features user image segmentation, behavior recognition, and 3D synthesis in real time. On the other side, a team of library staff, storytellers, 3D designers, and animation directors have designed and produced 10 experiential storytelling contents that elaborately lead children to read literature once they experience the content.

The first prototype was developed and installed at NLCY in 2010. After succeeding in 2 years of field tests, we have been deploying the system and contents in 20 public children's libraries with the support of the government policy for encouraging young children's literacy.

Design and implementation

Physical Space

In general, an isolated room equipped with a large display proves effective for virtual reality application where the sense of immersion depends on overwhelming visual and acoustic queues [6,8]. However, we found in early deployment that most users who are younger than 8 years old feel scared in a conventional immersive environment, dark and with strange sounds. Therefore, we decorated the side walls to give a friendly impression to children at first and installed different types of dimming lights to allow children to familiarize themselves with the dark space.

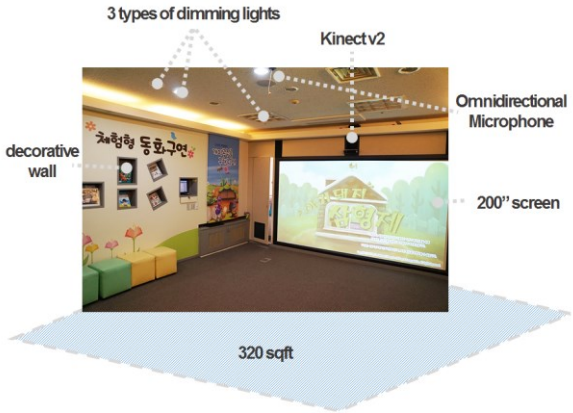

Figure 1. Kids in Fairytale space at NLCY

The role of parent remains significant in linking children' virtual experience to reading habits, they need to understand how their children feel, react, play at Kids in Fairytales. We therefore built an observation room to accommodate the parents and relieve their worries about their children as well. The screen and audio is lively shared so as to parents can see how their children are doing in the space. The observation room is also beneficial for research as it allow us to perform user study while not intervening in the space.

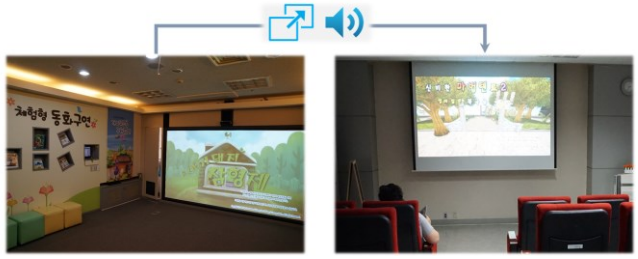

Figure 2. Kids in Fairytales room and Observation Room

3D mixed reality

Milgram well describes the basic concept of 3D mixed reality, which in general synthesizes real-word and virtual world scenes [7]. Our system is not far from conventional mixed reality applications except for the real-time 3D synthesis of the users' images. Figure 5 illustrates the key features and data flow of our 3D mixed reality system.

Figure 3. The process of 3D mixed reality featured in Kids in Fairytales.

Figure 4. The storyboard framework for Kids in Fairytales contents. This includes the 3D position of potential users (red box), users' activities, and interaction models.

USER IMAGE SEGMENTATION

The key of user satisfaction with a mixed reality system is how clearly and realistically they can see themselves projected into the virtual world. Human image segmentation has been deeply explored in computer vision research. Kinect is used for capturing user images as well as recognizing human behavior for interaction. In addition to using SDK's functionality, We implemented post-processing algorithms that separate each user's image with labeling, smooth the noise near boundaries, and adjust the brightness level of each image.

3D REAL-TIME SYNTHESIS

The user image is captured by a single camera, and most Mixed or Augmented Reality systems synthesize it as is (2d image) with a virtual image. In contrast to conventional systems, we extract each user's image by user image segmentation and its pivotal 3D position in real space. The segmented user image is then mapped to a corresponding 3D video map in the virtual world, which involves a real 3D–virtual 3D registration process introduced in [3]. By doing so, every user is placed at exact 3D position in the virtual world, and this enables both a 3D immersive experience and elaborate 3D interaction with the virtual world.

USER INTERACTION WITH VIRTUAL WORLD

Kinect SDK enables a lot of free-hand human interactions by providing skeleton information of users. Prior work [10,11] has centered on recognizing human behaviors (*e.g.,* postures, gestures, activities), not on how users interact with virtual 2D/3D content. Our research started from observing how users react to virtual 3D scenes or objects. Then most frequent behaviors of users for given various objects and scenes are selected as interaction models.

Storytelling contents

The goal of Kids in Fairytales contents is to first immerse pupils in a specific story in the virtual environment and then motivate them to read the literature afterward. We organized a team of library staff, storytellers, 3D designers, and animation producers to design, author, and evaluate the virtual storytelling contents. The process of publishing virtual content is more complicated and iterative than conventional one. First, many existing stories are examined for the significance in literature, children's interest, potential interactivity, and 3D feasibility. Once a story is chosen for reproducing, the team tunes the story for MR content. This involves several technical concerns, including where to put users in the virtual scene and what kind of interaction users should perform with the virtual world. All of the technical issues are carefully verified in early design steps and explicitly described on a storyboard. Figure 5 shows the storyboard framework used by designer and authors for embracing those concerns, which is also used for 3D designers and programmers to produce the content.

We found from early deployment a storyteller who can guide the kids, explain the virtual world, and elicit interaction is needed to smooth the overall play. The main role of a storyteller is to elicit interaction from the child (*e.g.,* interacting with virtual objects, singing along with the chorus, dancing with virtual avatars). A total of ten contents have been produced by May 2014 and four contents are coming in 2015.

Figure 5. The overview of Kids in Fairytales contents

Software implementation

The software of Kids in Fairytales is implemented as a distributed system that consists of two computers. We divide the whole software modules into two groups. The first group processes the user information obtained from Kinect and the other group is involved with 3D rendering. Task-parallelism is harnessed in overall architecture in order to meet the real-time performance requirement of image processing, interaction recognition, and 3D rendering. The most demanding part of the system is to process more than 10 processing algorithms of image segmentation and behavior recognition with no less than 20 FPS performance. To tackle this problem, we designed a plug-in framework that enables each plug-in module to run independently and in parallel while sharing common resources (user image, skeleton data, frame information) are shared among them.

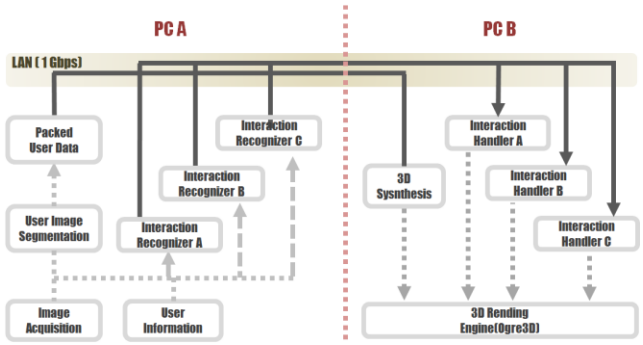

Figure 6. The software architecture of Kids in Fairytales.

Deployment

The first prototype of Kids in Fairytales was deployed in 2010 at NLCY, which is the national children's library located in South Korea. We performed 2 years of exploratory study that aimed to explore and solve technical, content, and usability issues. The official deployment was started with the support of a governmental campaign in 2012, and now a total of 20 children's libraries in South Korea have launched Kids in Fairytales. The accumulated number of visitors to the service at NLCY reached 15000 children this year, and it is actively in service today.

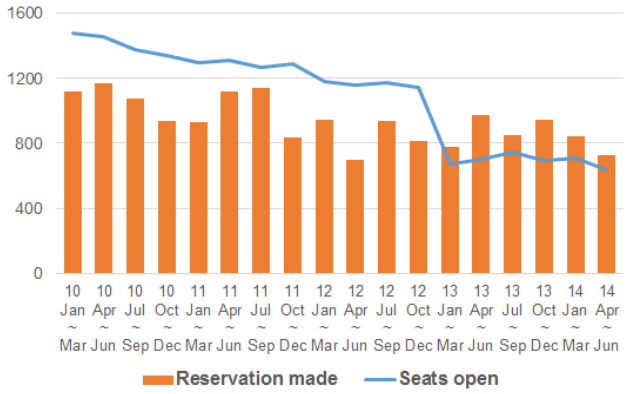

Figure 7. The reservation history of Kids in Fairytales at NLCY. All reservations are made via NLCY website (http://www.nlcy.go.kr)

Conclusion

Kids in Fairytales is a promising mixed reality application that provides virtual storytelling experience to young children so as to encourage their reading. Prior work similarly explored the potential of mixed reality, but the limitations of key technologies—computer vision and 3D graphics—made it difficult to come up with practical applications and content [1,5,12]. However the recent emergence of computer vision techniques has facilitated the implementation of

2D mixed reality, and several storytelling applications were introduced [2,9].

We have presented our experiences in developing and deploying the 3D MR system along with virtual storytelling contents. Thanks to the depth camera of Kinect and the graphic engine of Ogre3D, our research successfully resolves the technical issues which have impeded practical mixed reality applications. We also demonstrate that combining storytelling with mixed reality is a powerful way of enriching user experience especially with young children.

As future work, we plan to evaluate the user experience which expects to change children's reading habit and interest. We are also developing the authoring tool to ease content production by providing intuitive user interface specialized for mixed reality applications.

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