

Interactive Entertainment Systems Using Tangible Cubes

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ABSTRACT

In this paper we present two tangible interactive entertainment interfaces using physical cubes. In the first paradigm, Magic Story Cube, we novelly used a foldable cube for tangible and interactive story telling. In the second paradigm, Jumanji Singapore, physical dices are used to directly manipulate and control the process Jumanji board game. In both of our systems, we embedded both the concept of augmented reality (AR) and the concept of tangible interaction. More importantly, multiple modalities including speech, 3D audio, 3D graphics, and touch are used to provide the user with multi-sensory experiences. Our research explores the uses of tangible objects, more specifically, the uses of physical cubes in interactive entertainment systems.

Categories and Subject Descriptors

H.4 [Information Systems Applications]: Miscellaneous;
H.5.1 [Multimedia Information Systems]: Artificial, augmented, and virtual realities; H.5.2 [User Interfaces]: Prototyping

Keywords

Interactive Entertainment, Augmented Reality (AR), Tangible User Interface (TUI), multi-modal interaction

1. INTRODUCTION

Humans have been able to tell story, and play board games since ancient times. These formats of interactive entertainment have lasted almost throughout human history. As social creatures, humans find physical interaction, touch, and human-to-human presence essential for the enjoyment of life [4]. Nowadays, computer entertainment also can provide humans with enjoyment, by allowing virtual fantasy and imaginative play activity to be carried out. However, present computer entertainment focuses the user's attention mainly on computer screens or 2D/3D virtual environments, rather than interactions between humans. Physical and social interaction is constrained, and natural interactions such as gestures, body language and movement, gaze, and physical awareness are lost [8].

These limitations can be addressed by applying augmented reality (AR) and tangible user interface (TUI) technologies. Several researches have been carried on for storytelling purposes applying AR [5] or TUI [3] techniques. Our Magic Story Cube is differentiated by novelly applying a foldable cube as the interface. It enhances the entertainment experience by allowing users to physically unfold the cube to ex-

plore the story contents. As shown in Figure 1, our novelty lines in the fact that we apply Magic Book [6] technology in a 3D foldable cube [2] which enables a 3D direct tangible interaction by both hands. The storytelling becomes tangibly interactive for the user instead of passively showing the 3D graphics.

In the other system - Jumanji Singapore, we applied physical labelled cubes as essential elements of 3D board game - dice and controller. Our system applies the similar method to track the cube as in Fjeld's "Augmented Chemistry" [7], however instead of purely using the cube as a controller of 3D graphics, the cube itself now serves as an essential element (dice) of the board game. Apart from holding the collaborative entertained experience as in other AR board game [9], Jumanji Singapore also emphasizes tangible interactions. Both of our systems allow user to have multi-modal (3D vision, 3D music, speech, and touch) interaction for interactive storytelling and game entertainment while re-invigorates computer entertainment systems with social human-to-human and human-to-physical touch interaction.

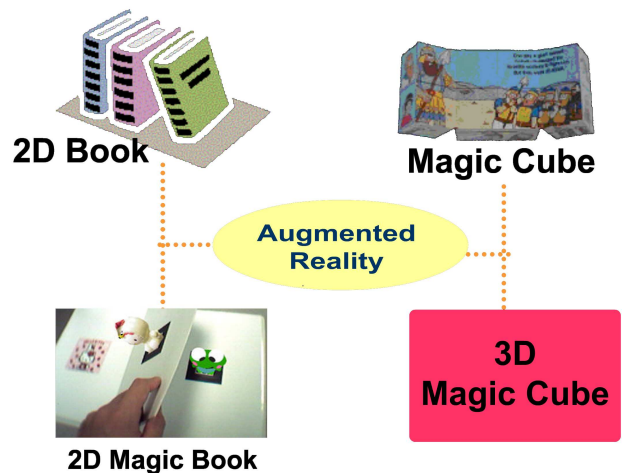


Figure 1: Evolution of books in storytelling. Our Magic Story Cube is a 3D version of Magic Book. It allows interactive tangible experiences with augmented reality story scenarios.

2. MAGIC STORY CUBE

Storytelling is an important part of human culture, both in entertainment and in education. Traditionally storytelling

enables multi-sensory experiences including audio (speaker’s narration), vision (text and pictures on the book) and touch (turning the pages). With the development of multimedia technologies, digital movies for storytelling on PC become possible. However, from the HCI viewpoint, the GUI-based storytelling interface constrains users on flat rectangular screens hence not only separates the story from the humans and the physical world, and also limits the use of touch (and thus limits the interaction modes).

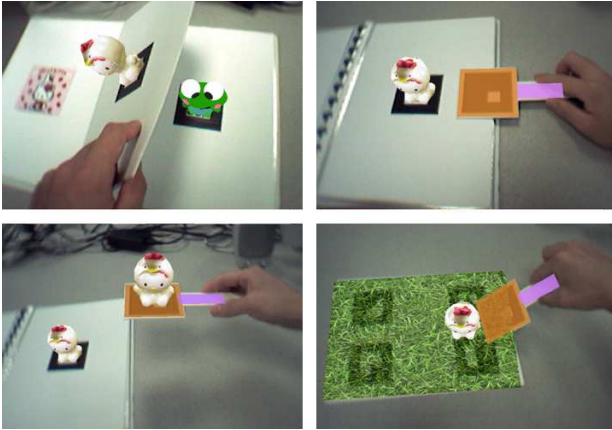


Figure 2: Traditional magic books only allow a planar physical manipulation.

“Magic Book” [6] technology encourages 3D interactions to the augmented virtual objects. However, the cards and paddles used do not very much improve the use of touch due to their flat 2D configuration. As shown in Figure 2, the users are limited to planar 2D touch (which is not like the natural real world 3D objects humans interact with). We address this problem by applying a foldable 3D cube instead of 2D book and 2D paddle which encourages two-hands manipulations. Figure 3 shows the physical setup of Magic Story Cube. User wears a head mounted display (HMD) with a camera mounted in front to provide the first person viewpoint of the 3D scenes while direct manipulating the process of the story by two-hands interactions.

Magic story cube applies a simple state transition model for interactive storytelling. Appropriate segments of audio and 3D animation are played in a pre-defined sequence when the user unfolds the cube into a specific state (as turning pages in a physical story book). The state transition is invoked only when the contents of current state have been played. The state transition is in a one-way manner thus only the first unused story segment will be played back, allowing the story to maintain a continuous narrative progression. In this example, Magic Story Cube tells a famous Bible story “Noah’s ARK” which is selected to be one of representative story of beginner’s Bible, as shown in Figure 4.

Magic story cube allows all modes of multi-sensory storytelling to be felt by the humans (audio, vision, and 3D physical touch). Our preliminary user feedback shows that most of the users feel much entertained when they can physically manipulate and explore the cubes to see and hear the story, compared to being passively given a video clip and a magic book.



Figure 3: Physical setup of 3D story cube: User wears a head mounted display (HMD) and views the 3D version of the story through the HMD while exploring the tangible foldable cube.

3. JUMANJI SINGAPORE

The “Jumanji” game [1] in the Hollywood fantasy movie lures players to its game-board via intriguing jungle drums. By rolling the dice, the player’s game piece moves magically along the board and the player navigates two different worlds - the deadly jungle world and the real world. We realize this fantasy myth in our real system “Jumanji Singapore” which allows users to have a magical tour of Singapore by simple manipulations of physical cubes.

AR technology aims at augmenting the physical world by superimposing computer-generated digital information, especially 3D graphics. TUI encourages the use of physical objects to interact with digital information in a more intuitive and natural way. Our Jumanji board game system combines the main advantages of both technologies by visually tracking the physical game-board and dice which allows user to play the game by physically rolling the physical dice while being able to transit among the physical world, 3D AR world, and 3D virtual reality (VR) world.

Our game system uses the map of Singapore as the game-board and two cubes with different markers mounted on each of the surface. One cube is used as the dice and the other one (called “control cube”) is used for more complex functions. Figure 5 shows the physical setup of the game. Our game system supports two players to play in turn. When viewed through the HMD, the game-board turns into a 3D map of Singapore with representative sceneries along the tracks.

3.1 Game rules

We designed simple game rules for Jumanji Singapore board game.

- Two users play the game by throwing the dice in turn
- User is not allowed to go forward unless she finishes the tour/shopping in the spot where she came across
- When gets to a crossing of the tracks, user is required to roll the dice again to decide which path to take

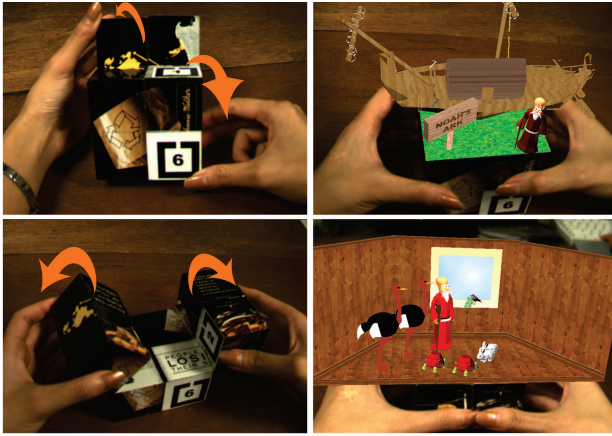


Figure 4: Magic Story Cube in action: In this example, the Magic Story Cube is telling a Bible's story - Noah's Ark. The user can use both hands to unfold the cube and explore the contents of the story. Corresponding 3D animation, 3D sound, and human narrative voice are played back in different states.

- When gets to the famous sceneries, the user is required to take a tour/shopping there for a few runs depending on the dice she rolls
- The one who firstly gets to the city center wins the game

3.2 Representative scenarios

We designed many scenarios in the game. Video clips, 2D photos, 3D models, and 3D sound of the sceneries are applied to provide the player with a multi-modal experience in the interactive entertainment environment. Here we summarize a few representative scenarios:

- The metaphor of the play on the map will move with regard to the points of the dice she rolls, as shown in Figure 6.
- When the play gets to a shopping street, she is required to do shopping by using the control cube to add goods into the cart (augmented on the top of the dice), as shown in Figure 7.
- The player arrives at the virtual Sentosa island. As shown in Figure 8, she is viewing the video clip of the Musical Fountain.
- The player can also use the control cube to decide which track to go when come to a crossing, to fly into and navigate through the VR world of the famous scenic spots, as shown in Figure 9.
- Player two gets to the end point first and wins the game. As shown in Figure 10.

4. CONCLUSIONS

In this paper we present two tangible interactive entertainment interfaces using physical cubes. The first paradigm,

Magic Story Cube explores the application of cube interface to the field of interactive storytelling. The narrative appears to be much more attractive and understandable by introducing 3D graphics and 3D sound as well as the 3D manipulation and 3D sense of touch. This also suggests that augmented reality technologies can be used to complement tangible user interfaces for a more exciting and entertaining interactive experience. The second paradigm, Jumanji Singapore, explores the application of TUI in building an augmented reality 3D game for entertainment and potential tourism promotion purposes. It also explores the use of physical cube as the essential element (dice) of board game. It allows the Hollywood fantasy to be turned into reality.

A web site featuring videos of these works can be seen at <http://mixedreality.nus.edu.sg/media-videos.htm>.

5. ACKNOWLEDGMENTS

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6. REFERENCES

- [1] British Columbia. Jumanji. [Online]. Available: <http://www.hollywood.com/movies/detail/movie/176803>.
- [2] Story Cube. Patent NO.: China# ZL 92 2 18681.6. http://www.magiccube.com/magic_cube.htm.
- [3] A. Mazalek, A. Wood, and H. Ishii. Geniebottles: An interactive narrative in bottles. In *Conference Abstracts and Applications SIGGRAPH 2001*, page 189, Los Angeles, California USA, August 2001.
- [4] J. Bowlby. *Attachment and Loss*. Volume I: Attachment, Basic Books, New York, 1983.
- [5] N. Braun. Storytelling in collaborative augmented reality environments. In *Proceedings of WSCG 2003*, Plzen, Czech Republic, February 2003.
- [6] M. Billinghurst, H. Kato, and I. Poupyrev. The magicbook: Moving seamlessly between reality and virtuality. *IEEE Computer Graphics and Applications*, 21(3):2-4, May 2001.
- [7] M. Fjeld and B. Voegtli. Augmented chemistry: An interactive educational workbench. In *Proceedings of IEEE and ACM International Symposium of Mixed and Augmented Reality (ISMAR 2002)*, pages 259-260, Darmstadt, Germany, September 2002.
- [8] R. L. Mandryk and K. M. Inkpen. Supporting free play in ubiquitous computer games. In *Workshop on Designing Ubiquitous Computing Games, UbiComp 2001*, Atlanta, Georgia, USA, October 1991.
- [9] Zsolt Szalavri, Erik Eckstein, and Michael Gervautz. Collaborative gaming in augmented reality. In *Proceedings of VRST'98*, Taipei, Taiwan, November 1998.



Figure 5: Physical setup of Jumanji Singapore Game: User wears a head mounted display (HMD) and views the 3D map of Singapore through the HMD. User need to roll the physical dice to play the augmented reality game.

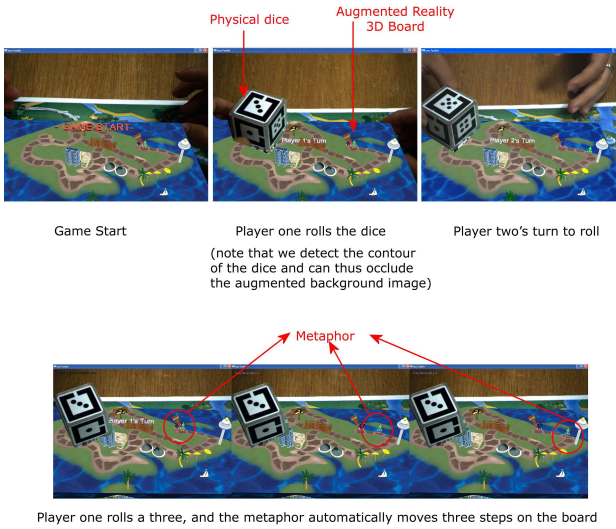


Figure 6: Jumanji Singapore in action

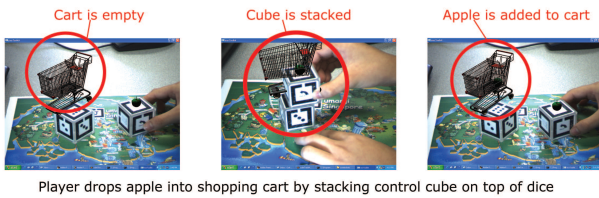


Figure 7: Using the cube to have a virtual shopping in city center of Singapore.

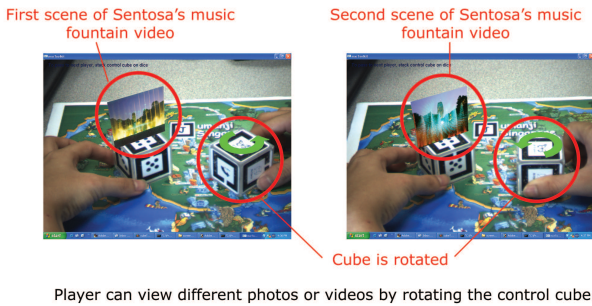


Figure 8: Using the cube to see the photos and video clips of Sentosa Island of Singapore.

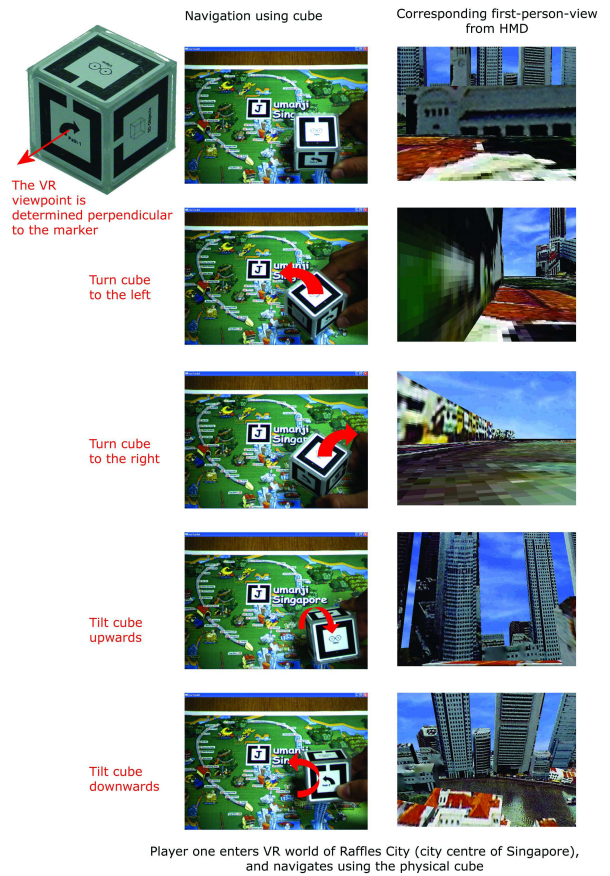


Figure 9: Using the cube as a navigation tool to tour in virtual Singapore city center.



Figure 10: Player two gets to the end first and wins the game.