A Context-Based Storytelling with a Responsive Multimedia System (RMS)*

Youngho Lee, Sejin Oh, and Woontack Woo

GIST U-VR Lab., Gwangju 500-712, S.Korea
{ylee, sejinoh, wwoo}@gist.ac.kr
http://uvr.gist.ac.kr

Abstract. In this paper, we present a Context-based Storytelling with Responsive Multimedia System (RMS). Many researches related to virtual storytelling have been presented with the advancement of multimedia technology. However, people have different abilities to understand a story according to their experience, knowledge, age, gender, etc. In the proposed approach, virtual story is unfolded by interaction between users, Multi-modal Tangible User Interface (MTUI) and Virtual Environment Manager (VEManager) with vr-UCAM (a unified Context-aware Application Model for Virtual Environments). We adopt an interactive StoryMap and tangible interfaces into MTUI with vr-UCAM such that VEManager can control the responses of virtual objects according to the user's context. Accordingly, the users can experience a personalized story since action of virtual objects, interaction level and scene of VE are reorganized and adjusted according to a user's profile and preference. To demonstrate the effectiveness of the proposed approach, we applied it to a virtual storytelling with RMS. According to the experimental results, we observed that the combination of virtual reality technology and context-aware computing could be promising technologies that enables users to experience a personalized virtual story. Therefore, we expect that the proposed approach plays an important role in virtual storytelling applications such as education, entertainment, games, etc.

1 Introduction

With the rapid advancement of hardware and software, entertainment computing industry has been popularized during the last decade. These multimedia technologies have brought huge changes in traditional storytelling. In general, books, movies, and animations follow Aristotle's Poetics which is proper for evoking feelings and emotions of readers. However, many research activities of storytelling using novel multimedia technology have presented new narrative structure which is different from traditional structure [1][2]. In the novel multimedia technology, it is necessary to balance interactivity and narration. Thus, we need to balance between story designed by an author and emergent story unfolded by participants.

There have been three kinds of approaches to achieve the interactivity of storytelling. Plot-based approach is a plot management system which is used to directly control actions of characters, leaving only the lowest level of behaviors [3]. In character-

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based approach, broad and believable autonomous characters are placed before the player, and then a story emerges from the player's interaction [4][5]. The last one is author-based approach. This approach could be modified to be of use in interactive stories. One of characteristics in previous approaches is in controlling a balance of interaction and narration. They showed a lot of interesting results, however, they did not consider a user's level of understanding, even though persons have different abilities to understand a story according to their knowledge, experience, age, gender, etc

In this paper, we present a Context-based Storytelling with Responsive Multimedia System (RMS). In the proposed approach, virtual story is unfolded by interaction between users, Multi-modal Tangible User Interface (MTUI) and Virtual Environment Manager (VEManager) with vr-UCAM (a unified Context-aware Application Model for Virtual Environments). We adopt an interactive StoryMap and tangible interfaces into MTUI with vr-UCAM such that VEManager can control the responds of virtual objects [6]. User's context, such as profile and preference, are applied to initialize whole system before beginning a story, to make an event sequence designed by an author and to select responses of virtual objects in VE.

From the proposed approach, users can interact with VE intuitively since they easily understand the use of interface. Moreover, users can experience a personalized story in which actions of virtual objects, interaction level and scene of VE are reorganized and adjusted according to a user's profile and preference. VE. Consequently, we can control the balance of interactivity and narration by exchanging interactive StoryMap according to the user's context.

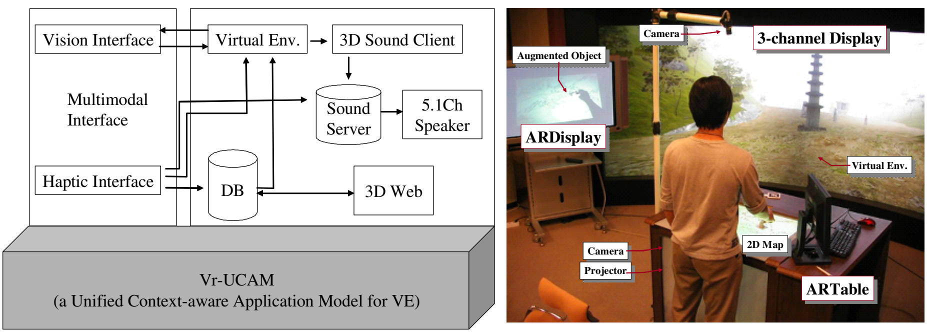
To demonstrate usefulness of the proposed system, we implemented a virtual heritage system which represents legend of *Unju Temple*. Firstly, 2D animation shows legend of *Unju Temple*. Thus, it makes participants understand plot and motif of the historical place. To experience actually the virtual heritage system, users input their profile on PDA, and select a specific doll according to their preference. Then, StoryMap guides the participants to the 7 places which show adaptive events according to the user's profile acquired by PDA. Users can make their own story by manipulating the tangible interface interacting with StoryMap and VE. Accordingly, we believe that the proposed system can be applied to the application areas, such as historical education, interactive entertainment and games, etc.

This paper is organized as follows. In Section 2, we describe detailed components of RMS. In Section 3, we show implementation of the heritage system. In Section 4, we describe a presented story in our implemented system. Finally, the conclusions and future work are presented in Section 5.

2 System Overview of Responsive Multimedia System (RMS)

RMS consists of three key components; a multi-modal tangible user interface (MTUI), a Unified Context-aware Application Model for Virtual Environments (vr-UCAM), and virtual environment manager (VEManager) [7][13]. MTUI allows users to interact with virtual environments through human's senses by exploiting tangible, haptic and vision-based interfaces. vr-UCAM decides suitable reactions based on multi-modal input [6]. Finally, VEManager generates dynamic VE through 3D graphics and 3D sounds, etc.

We integrated MTUI (such as, haptic interface, ARTable, 3D Sound system), VE-Manager, and vr-UCAM into the RMS. Fig. 1(a) shows the structure and describes information flow of RMS. We built Database and Sound server to save 3D Model and to play 5.1 channel sounds. With the haptic interface, we deformed 3D model and delivered it into the DB over the network. We displayed the deformed contents in VE and we downloaded it from the 3D web site. We connected ARTable, Haptic interface and VE with sound server. When triggered signal was delivered to the sound server, it selected proper sound file to play through 5.1 channel speaker. Moreover, we designed 3D web server to allow users to interact our contents over the network. To demonstrate the propose RMS, as shown in Fig. 1(b), we exploited various equipments, such as, three-channel stereoscopic display system, the clustered 3 workstations for cylindrical 3D stereoscopic display, 2 workstations for vision-based and haptic interface, and 1 workstation for sound and database server.



(a) (b)

Fig. 1. Overview of RMS (a) System Architecture and (b) Demonstration of RMS

3 User-Centric Context-Based Storytelling

3.1 User's Context and Its Application

Context is responsible for unfolding the story with sequences of events, execution of events, interaction level, and for changes in VE. Firstly, we can compose different event sequences according to the user's personal information. Secondly, we can offer different events, e.g., if someone selects 'good' mode, he can watch blooming trees. Or others can watch shaking trees by wind. Thirdly, we can also adjust proper interaction level according to users. For example, if a young child experiences a virtual story, we need to restrict degree of freedom of user interface since the child does wring actions as he/she wants. However, if an adult experience a virtual story, we can recommend proper actions for building a story. Finally, we provide users with personalized VE. For example, weather and lightning can be changed according to the user's preference.

The context of a Virtual Storytelling is categorized with explicit context and implicit context. Explicit context indicates a direct command such as gesture, pressing button. Implicit context means personal information or preference. The context supports seamless connection between RE and VE by exploiting as a form of 5W1H [10] [11]. Moreover, we apply two methods to extract context; WPS (Wearable Personal Station) for implicit context, sensors for explicit context. WPS manages the user's needs and preferences [12]. When we want to acquire context by sensors, it depends on target and the sensor type. For example, if we use a vision interface, we can get the user's gesture or position by processing video frames.

3.2 Framework for Context-Based Storytelling

We assume that a virtual storytelling is achieved by interaction between real and virtual environments. From this point of view, we divide the environments into four parts: users, surroundings, virtual objects and virtual surroundings. Story is unfolded with collaboration of users, MTUI (surroundings) in real world and virtual objects, virtual surroundings in VE. As shown in Fig. 2, users, MTUI and VE are connected as an input and output relationship by using vr-UCAM. For instance, multimodal tangible user interface, e.g., dolls and watch, are connected to virtual object (avatars) and time of day in VE. So, when users manipulate user interface, the results are displayed in the VE. On the other hand, an action of virtual object in VE affects states of user interface.

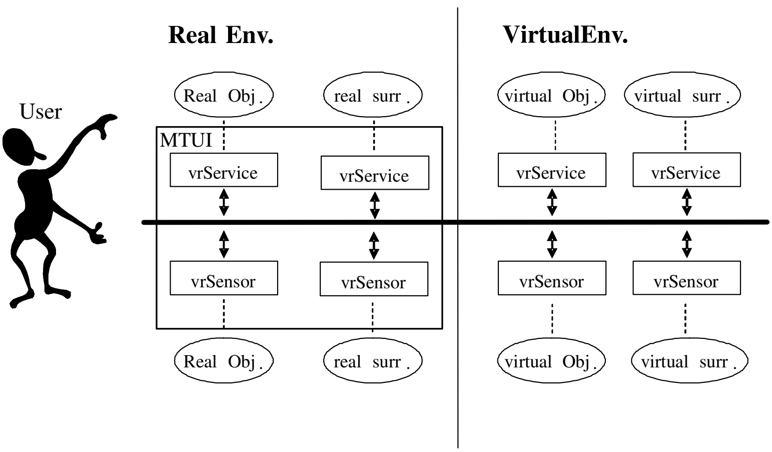


Fig. 2. Relationship between a user, RE and VE. A user interacts with tangible interface in real environment.

vr-UCAM is a framework for designing context-aware applications in virtual environments[6]. It is focused on implementation of intelligent objects which response according to the user's context. To extract the user's context, actual or virtual sensors acquire raw signal, and then generate the preliminary context which only contains limited information according to the sensor's ability. Furthermore, virtual objects and virtual surroundings integrate several contexts from sensors, and determine proper responses. That is, through acquisition, delivery, and processing step, they understand not only explicit input but also implicit input of users. After understanding the user's intention, the applications decide and show pertinent responses.

Based on vr-UCAM, we design architecture for context-based storytelling by exploiting user's profile and preference. As shown in Fig. 2, it consists of users and MTUI in real environments, and virtual objects and virtual surroundings in virtual environments. The users provide personal information to the MTUI and VEManager. Both MTUI and VEManager reflect user's personal information on their application. MTUI guides users to experience a virtual story by composing sequences of events in VE and VEManager controls actions of virtual objects in VE. The author can design MTUI and VE according to story. In this architecture, MTUI, which is composed of Tangible interfaces and Interactive StoryMap, has a role to make a sequence of events in VE by depending on the author's design and the user's interaction.

3.3 Tangible Interface and Interactive StoryMap for Narrative Control

Tangible interface allows users to approach and interact with VE. In details, we classify the tangible interface with media object and control object [8][9]. The media object makes users approach multimedia contents in virtual environments. And the control object offers an intuitive interface which allows users to manipulate VE with their two hands. The tangible interface is designed as a form of objects, e.g., small priest, etc, related to the story.

Interactive StoryMap has an important role to reorganize and adjust a virtual story. The Interactive StoryMap displays images to guide users to author's storyline at the ARTable of RMS [7]. It allows users to interact with VE by manipulating tangible interface and Interactive StoryMap. In VE, there are lots of events at the location. Users read different information on the StoryMap and they visit different ordered locations, since it shows different guide map of VE.

3.4 Action Control of Virtual Object and Virtual Surrounding

Virtual object and virtual surrounding in VE have their own actions which are based on the finite state machine. They are also designed as a form of characters related to the story. For example, let's assume that there are a tree which has three states; standing up (no moving), moving by wind, and blooming flower. We change the states according to the decision of vr-UCAM.

State of a virtual object indicates the action taking by the virtual object. A transition is a condition that the virtual object can turn from the current state to other state. It is expressed $C = < P, T, E >$ to a total model, $P = \{p_1, p_2, \cdots, p_n\}$ is a set of state, and it is expressed as a circle, $T = \{t_1, t_2, \cdots, t_m\}$ is expressed with a quadrangle by a set of a transition. E is a set of arrow and $E \subset (P \times T) \cup (T \times P)$. The state of a virtual object can be shown with m:P ({0,1}. This means that a position and the number of token are put in a circle. Thus, we can express the state of virtual object as $m = [m(p_1), m(p_2), \cdots, m(p_n)]$. For example, let's assume that initial state of virtual object is $m = [1,0,0,0]$. If virtual object receives a triggered signal t_2 from vr-UCAM, the state of a virtual object move to p_2 and it is expressed as $m = [0,1,0,0]$.

4 Implementation

4.1 Legend of Unju Temple

Unju Temple is a temple located in Daecho-ri, Hwasun-gun, Jeonnam Province in Republic of Korea. At the end of Unified Shilla Dynasty, Reverend Priest Doseon tried to construct thousands of Buddhist statues and stone pagodas in a single night. By implementing the history, we try to show wishes of ancient people, who put tremendous amount of effort building Buddhist structures, and the beauty of Unju Temple. We also apply the following scenario: *Users watch animation or listen the legend of Unju Temple. They go to carve a Buddhist statue and station by using haptic interface. After completing to make the Buddhist statue, they move it to virtual environment. They start to navigate virtual Unju temple. There are seven events to unfold the story as user's positions. In addition, users can experience Unju Temple repeatedly through 3D web site.*

4.2 vrSensor and vrService from Story

To design the introduced virtual story, we processed following steps. At first, we assigned events on the seven specific locations. From these events, we designed virtual objects and MTUI which interact with users. Moreover, vrSensor and vrService were implemented and attached to the objects and surroundings. Table 1 shows the context list which can be extracted from implemented vrSensors in the proposed RMS [7].

Table 1. Context List

	Context	Sensor
Real Env.	Coordinate of object in Table	Camera Tracking System
	Time of RE	Time sensor
	Weather of RE	Weather caster or simulator
Virtual Env.	Location of VE	Location sensor in VE
User	Age, gender	PDA
	Preference (animals, color, weather)	User's selection on Table display and tangible objects

Table 2. Seven Events in the implemented virtual Unju

Location	Events description
Great Tree in front gate	When user gets close to Great Tree, the user can hear sounds of wind and birds.
Road of Pagoda	Priest Doseon appears and disappears repetitively to guide direction
Cherry blossom	Cherry reacts according to user's gesture and context.
Field of Small Pagoda	User can station small pagoda and wish his/her desire. It records voice of the user.
Construction Rock	Stars twinkle up in the sky. Pagoda and Buddhist twinkle on the ground.
Maeyeorae	User can watch ruins of Maaeyeorae
Lying Buddhist	Priest Doseon appears and then user can watch lying Buddhist at one sight from higher position. When enough number of pagodas is stationed, lying Buddhist starts to stand up.

In addition, Table 2 shows events based on the legend of Unju temple. We designed user's interaction focusing on 'field of small pagoda' and 'lying Buddhist' since we want to show the desire of ancient people. We also categorized the RMS into real surrounding, virtual object, virtual surrounding, regarding the scenario shown in Table 3. Then, we described interaction between these four elements according to the user's context.

Table 3. Actions of vrSensors and vrServices

vr-UCAM	Name		Actions
vrSensor	Real surrounding	vrController	Senses a user's gesture from motion of object
		vrWeatherforecaster	Detects current weather state
		vrTimer	Acquires current time
	Virtual surrounding	vrLocationSensor	Senses location of a user's avatar in virtual Unju
vrService	Real surrounding	vrViewer	Displays maps or pictures on MTUI
	Virtual object	vrNavagator	Changes the camera path
		vrDoseon	Appears or disappears when he want.
		vrMaae	Begins to Ruin according to time.
		vrPlant	Grows and Blooms
	Virtual surrounding	vrWeather	Changes the color of sky, location of sun, fog in VE
		vrSound	Generates specific sounds

4.3 Tangible Object, Interactive StoryMap, and Events in VE

We implemented Multi-modal Tangible User Interface to unfold virtual story. We made several kinds of dolls, e.g., a small priest, a tiger, and a dragon, etc, related to the story, and participants can select one of them according to their preferences. For building stone pagodas, we made shovel-shape object. So, participants can move stone with shovel-shape object. Furthermore, we connected a physical watch with time in VE, and then we used the watch to allow participants to change position of sun in VE.

We also implemented interactive StoryMap which was displayed on ARTable of RMS as shown in Fig. 3. It was designed for guiding or causing user's interaction. The StoryMap showed geometric information of 'Unju Temple'. When participants invoked interaction, specific position lighted up to guide next position to go. It can show different story since a author or a developer can change sequence of event.

We implemented Virtual Plant, Priest Doseon, and ruining Maaeyeorae. We created key frames of virtual object and combined them as a sequence by using pfSequence. A pfSequence is a pfGroup that sequences through a range of its children, drawing each child for a specified duration. Each child in a sequence was thought of as a frame in an animation. We controlled whether an entire sequence repeats from start to end, repeats from end to start, or terminates.

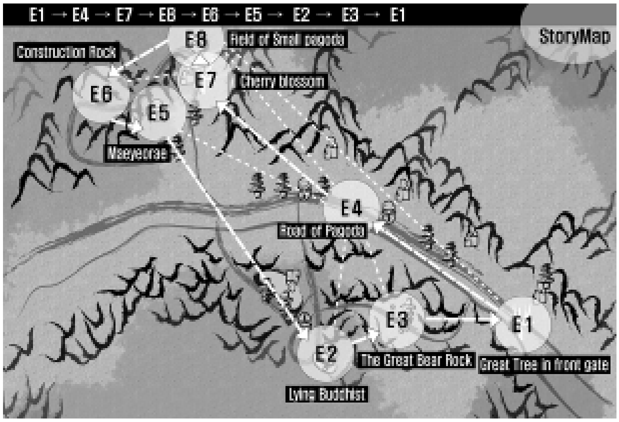


Fig. 3. Interactive StoryMap on ARTable

4.4 Scenario of Virtual Storytelling Based on User's Profile and Preference

At first, participants inputted personal information on PDA instead of WPS. We used this personal information to initialize overall system. i.e., we determined sequence of location, events, interaction level, and surrounding of VE. For example, if the participant was a young child, we selected a simple sequence of event and low interaction level because the young child was difficult to follow full story. And the child's interaction was restricted specific position which guide presented story. If the participant was an adult, we showed recommendation of next position, and then the participant could select the next event. Participant's preferred color and mood affect the weather in VE. If the participant chose one of rainbow color, one of mood (bad, good), it changed the color of sky and fog, raining, sun shining in VE.

The participant started interaction with objects and interactive StoryMap on ARTable. The participant watched objects, which is easily used in our daily life, on the table. There were three kinds of dolls (small priest, tiger, and dragon) for navigation and a bottle for pouring water. The participant could select one of dolls. If he selected the tiger, he crept toward front as in a view of tiger in VE. If the small priest was selected, screen view slightly moved up and down as human walking. If the dragon was selected, screen view rendered at the view point of flying dragon.

The first position where a participant put his/her doll was the entrance of 'Unju Temple' at StoryMap. When the participant arrived at the entrance, the entire map was changed to the detailed map. In the map, the participant can navigate near the entrance as he/she wants. The participant watches big tree moving by wind, and listen a sound of bird moving around the tree. When the participant placed the doll at specific position on the map, he exited out to entire map. Then, he recognized the recommended position with shining effect. He can select other position for further navigation.

After watching scenery on the path, the participant moved to the location where cherry blossom was planted. As explained above, the state of cherry was initialized according to the user's profile. We implemented three state; steady, shaking, flower. At this position, the participant poured the water to the plant by using object on table. Then the cherry bloomed beautiful flowers.

The next location was the field of small pagodas. It represented the desire of ancient people. At this location, the participant piled up small stones in VE and recorded their personal desire during 10 second. The participant grabbed an object which has a shape of shovel and holds a small stone on the table display. After the participant built a small pagoda with three stone, recoding voice started. The recorded voice file was saved to DB server. Finally, the small stone pagoda was moved to the field of stone pagodas in VE.

And the participant experienced several events at the next location. When the participant arrived at the rock of construction, he can watch the whole sight view of 'Unju Temple' and special event occurs. The pagodas and Buddhist status on the road twinkled at the road and it showed constellation. At Maaeyeorae, the participant watched the ruinous statue. It tells us absence of a thousand years.

Finally, the participant reached at lying Buddhist. According to the legend, when thousands of Buddhist statues were made, the lying Buddhist stands up right. In our story, when 10 small stone pagodas are made by participants, the lying Buddhist stands up right and recorded sound at the field of small pagoda played. After ending, the participant can visit any place and any events in VE.

5 Conclusions and Future Work

In this paper, we presented the context-based storytelling with Responsive Multimedia System (RMS). In our proposed approach, users can interact with VE intuitively through implemented tangible interfaces. Moreover, users can experience a personalized story in which events, interaction level and scene of VE are reorganized and adjusted according to a user's profile and preference. Consequently, we can control balance of interactivity and narration by changing interactive StoryMap according to the user's profile. In the future, we have plans to find evaluation method to improve our storytelling approach. In addition, we need to develop authorized tools to make contents and stories with RMS. Furthermore, we will apply the concept of artificial life for the virtual object.

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