The Development of a Collaborative Virtual Heritage Edutainment System with Tangible Interfaces

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Abstract. This paper presents an interactive, collaborative virtual heritage system that employs tangible interfaces to make learning experience more interesting and effective. The system is designed for a group of users collaboratively play games to learn a Korean cultural heritage site, the 'Moyang' castle. While most virtual heritage applications focus on the reconstruction of objects or places, it aims to encourage the visitors to get more involved with the activities and increase social interaction to develop collaborative learning experiences. This paper describes an overview of cultural meanings behind the 'Moyang' castle and some details in the system design and implementation for interactive education.

Keywords. Virtual Heritage, Game, Tangible Interface, Collaborative Learning

1 Introduction

Nowadays, museums are adapting more interactive techniques for exhibitions and public programs to provide memorable experiences [1]. With the fast growth of the virtual reality technology, it is possible to realize an immersive environment that enables users to experience interactive narratives that promote new patterns of understanding cultural heritages. Recently, interactivity has gotten more attention in the design of virtual heritage applications, such as the use of intelligent tour guide agents, game-style design approaches, and multimodal user interfaces, to increase user's cultural experience and give innovative ways of storytelling behind the scene [3]. The other approaches include the shared virtual heritage environment that allows distributed visitors to navigate the world, examine the architectural details and landscape from different perspectives, and meet with other visitors to develop shared VR experiences [3].

In this paper, we present the development of a virtual heritage system that encourages a small group of co-located users to play collaboratively to learn history and cultural meanings of a Korean traditional castle, 'Moyang-sung', using tangible

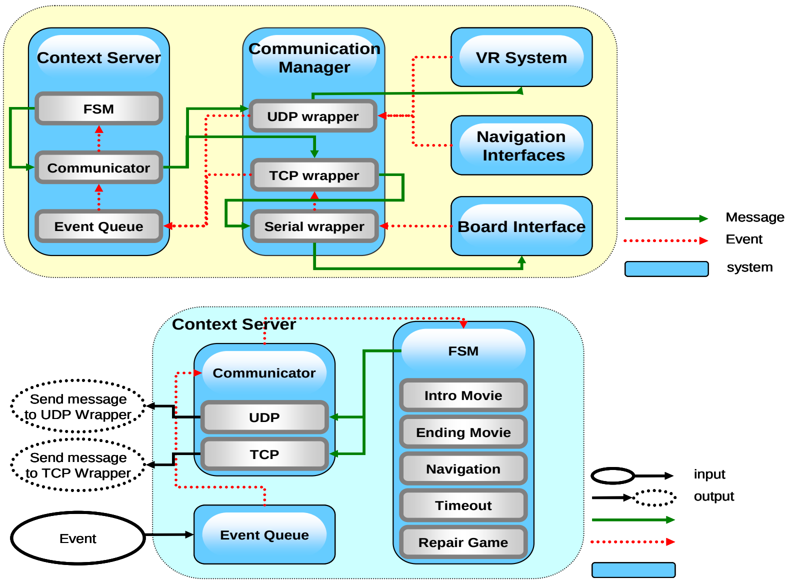

Fig. 1 The overall system architecture showing event and message flows among the sub-components (top) and the internal structure of context server (bottom).

interfaces. The castle has a legend called Dapsungnori, which says if anyone goes round on the top of the entire wall three times, he/she can go to the heaven. Our system consists of three main subsystems: the context server, the virtual environment, and the tangible interfaces. Instead of a traditional VR input device like a wand, the tangible interfaces are provided to give a transparency of user interaction with the virtual environment [2]. The tangible interfaces include the 'Matdol (a Korean traditional hand-mill)' interface and the touch-screen interactive navigation map for mimicking 'Dapsungnori', and the building block puzzle game board interface. The board interface allows multiple co-located users to do brickwork by placing tangible blocks on the board to help the group of co-located users engage in the activity together in order to increase social interaction and to develop collaborative learning experiences.

In this game, the users are given a mission to find the destroyed walls and repair the damages as soon as possible. The game task involves the users to walk around the castle walls to find the destroyed parts. Once they find the damage, the same pattern of damage is displayed on the board interface, and the users repair the wall by putting the tangible blocks (i.e., Tetris-pattern blocks made of transparent acryl and magnets) on top of the pattern. The context server maintains the game state from the start to the end as the users interact with the virtual environment and the tangible interfaces. The game ends successfully when the users complete repairing the four damaged walls within 10 minutes, and as a reward of the completion, the users receive an opportunity to experience virtual 'Dapsungnori'. When the game is over with failure, the users will see the whole castle destroyed.

Fig. 2 The tangible interfaces - the Matdol interface (left), the touch-screen interactive navigation map (center), and the tangible blocks and board interface (right).

2 System Design and Implementation

Fig. 1 shows the overall architecture of the 'Moyang-sung' edutainment system with the event and message flows among the sub-components of the system. The system consists of three main parts: the context server (including the communication manager), the VR system, and the tangible interfaces (i.e., the navigation and the board interface). The context server manages the main game logic and its communication manager controls the event and message handling among the sub-systems. The VR system contains graphics, sound, user interaction, and event processing modules. The tangible interfaces are the navigation devices (one using Korean hand-mill 'Matdol' metaphor and the other, the interactive navigation map) and the building block board. The 'Matdol' interface allows users to rotate its handle to walk through the pre-defined path along with the exterior of the Moyang-sung castle. The touch-screen interactive map shows the layout of the castle and the user positions. The communication manager is connected to the context server via the TCP while the board interface is connected to the communication manager. Communication between the board and the context sever is connected by a transmitter. The transmitter intermediates the RS485 (for the board) and the TCP (for the context sever) protocol. It monitors the board in a half-duplex method.

The context server processes the main logic of the game environment. The context server manages the finite state transition. When users put the tangible blocks on the board interface for damage repair in the virtual environment, an event is generated and the board puts it into the event queue of the context server through a transmitter. The environment is designed for a group of users to sit next to each other and participate in the tangible VR experience together. They can walk through the virtual world using the Matdol or the interactive map interface. The users can move left or right along with the pre-defined path facing the exterior of the virtual Moyang-sung castle by manipulating the 'Matdol' handle.

Fig. 2 shows the 'Matdol' interface, the interactive navigation map, and the tangible board interface used for the 'Moyang-sung' edutainment system. The

‘Tetris’-like tangible board interface are provided for users to do brickwork for repairing the damages on the wall. The board consists of 10x10 uniform square cells (40x40 mm^2 for each cell). The users can play the puzzle with five different shapes of blocks (i.e., I, L, T, cross, and square shape) on the board. In the repair mode, the destroyed pattern which is the same pattern shown in the virtual environment is displayed on the board. The block placement or removal on the pattern will be reflected into the virtual wall. Each tangible block has a magnet that can turn on the magnet sensor switch embedded on each cell of the board. The LED lights embedded on the board can light up the multiple-colored pattern to indicate the destroyed part of the wall. This tangible board interface is particularly designed for multiple user applications to play the game together to increase social interaction. However, a single player can also enjoy the system.

3. Conclusion / Future work.

In this paper, we presented a collaborative edutainment system using the VR and the tangible navigation and the interaction interfaces for cultural heritage education. The system is designed for a group of co-located users to play games collaboratively in the virtual environment using tangible blocks and enjoy the shared cultural learning experience. Unlike other virtual heritage applications that focus on the reconstruction of cultural objects or places, this system encourages social interaction among users which will help them be more engaged in the learning activities. In the near future, we will also conduct a user study of evaluating the system for collaborative learning as compared to single user learning. We expect that cooperative learning will be more successful in a complex problem solving task because it will help users see the same problem in various perspectives.

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