

Development of a Virtual Reality Game for Cultural Heritage Education : The Voyage of “Gotheborg”

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Abstract—Video games have been recognized as one of the most engaging forms of entertainment today, and are making a major contribution to the digital future. This research aims to combine the gaming elements of game design and virtual reality technology, and promote cultural heritage education through an engaging and fun experience, especially in a young population. Firstly, we summarized game mechanics and elements used for cultural heritage education through game product analysis and literature review. Secondly, we developed a virtual reality game for cultural heritage education that reproduced the voyage of “Gotheborg” to Canton, including game mechanic, game story, aesthetic expression and game technology. Finally, a pilot test was conducted to validate the effectiveness of our game developed. Our study contributes interdisciplinary research by bringing together currently distinct approaches from virtual reality technology, game design, cultural heritage, and education. It will bring new technology to impact on the digital media, cultural heritage education, and service industries.

Keywords— *virtual reality, cultural heritage education, video game*

I. INTRODUCTION

Virtual reality (VR) technology is an emerging field that combines the latest advancements in computer graphic, artificial intelligence, and display technology.

Currently, cultural heritage education is facing an increasing pressure to adjust and adapt to the needs of younger generation described as the Digital Natives. They grew up with digital products and have very different learning styles and learning cultures. As an educator of “digital immigrants”, we must provide new teaching methods and learn to communicate with youth in their own language. Educational games based on virtual reality technology are just a kind of teaching innovation needed today, while digital games have become one of the main entertainment ways of youth and have a profound impact on their learning and cognitive style [1]. The unique advantages of game interaction based on VR make it especially suitable for experiential learning and immersion learning in cultural heritage education. Moreover, educational games can better factor in students motivation and interest, building an attractive constructivist learning environment.

Our research explored reality technology including motion graphics and immersive scenarios to develop a game for cultural heritage education, providing a new form of inheritance and protection of the cultural heritage.

A. Cultural Heritage Education and VR

Cultural heritage education is an important way to inherit excellent traditional culture, raise awareness of cultural heritage protection, and promote the public to actively participate in the protection for cultural heritage. Since 1995, the United Nations Educational, Scientific, and Cultural Organization has organized several World Heritage Youth Forums for young people. VR technology could be a promising resource for cultural heritage education, especially on how to apply modern technological achievements in digitalization of cultural heritage. According to the Grand View Research, the global virtual reality game market was estimated at USD 4.29 billion in 2016 [10]. It is reported that by 2025, China is expected to replace the United States as the largest market for video games equipped with VR technology.

In 2009, the digital sculpture project in the United States first applied VR technology for protection of cultural heritage, and then, the Cathedral of Santiago in Spain, the Notre Dame in Paris and other world cultural heritages also used digitalization of ancient buildings through 3D modeling and virtual interaction technology with the help of VR. The combination of VR technology and cultural heritage can bring audience a totally new interactive and immersive experience, from passive watching to active participating. For instance, the Digital Dunhuang is a digitalization project of the Dunhuang Cave that transform cultural heritage into visible digital achievements, with the helping of virtual reality, augmented reality and interactive reality. It provided a compelling virtual tour of the Dunhuang Cave for a diverse of audience who are restricted by geographical distance before, such as user from abroad [3]. Buonincontri indicated that VR has become one of the most prominent innovations in the tourism industry in the past few decades, providing cutting-edge technology for tour operators to enhance customer experience [4]. Mura believed that VR has been recognized as an enhancement of heritage experience and is considered as a supplement (rather than a substitute) to real

tourism experience [5]. VR enhances visitors' experience of cultural heritages through participation, enabling new methods of interactive exhibitions inside and outside the museum. Researchers created a virtual tour to the (non-) tangible cultural heritage of Chinese temples in Singapore, providing a detailed framework of establishing virtual tours [6]. Tanaka developed a VR application called Virtual Kyoto which reproduced the world cultural heritage of Gion Festival in Kyoto [7]. Osorio designed a VR project to documenting artifacts at the gold museum in Colombia, enabling visitors to touch, hear and see virtual approximations of real objects [8].

B. Educational Game

Educational game is a game software that is specially designed for teaching purpose, which is used to help students learn specific subject knowledge, understand a certain concept, and acquire target skills. Ijaz developed an educational game that simulates Uruk, the earliest city in human history, and reproduces the architectural features and daily life of its residences more than 5,000 years ago [9]. Their research also compared the differences between the game learning and the traditional textbook and documentary teaching, and pointed out that students scored an average of 20% higher than the traditional learning group in the subsequent history test. Akkerman designed an educational game about the medieval history of Amsterdam, in Dutch, which greatly improved students' learning motivation and enthusiasm for participation [10]. Watson developed a computer game called Making History, which is used to assist history teaching among senior high school students. The results showed that students' participation in learning was more active and achieved a higher score [11]. Antoniou provided a design model for cultural heritage games, and designed several games for the exhibition and publicity of ancient Greek archaeological sites and museums, which were positively evaluated and welcomed by the audience [12]. It is concluded that in history learning, compared with traditional textbooks, educational games can effectively motivate students improve knowledge acquisition and understanding of complex concepts.

II. GAME DEVELOPMENT

A. Game Concept

Designing a game that is both enjoyable to play and effective at learning is a challenge, and the design process requires an incorporation of both an educational dimension and a game dimension. The educational dimension specifies the learning objectives of activity, which determines how to integrate the game as a learning environment. The game dimension defines what game elements should be designed to achieve the desired experience in order to ensure the fulfillment of the learning objectives. Furthermore, the game dimension of design process is subject to the educational dimension and unlike entertainment games, the elements of educational games are constrained by the learning objectives [13].

The game genre we chosen for the present project is the Role-playing Game (PRG), which is particularly suited to interactive and experiential learning. Scenario-based role-playing games (RPGs) have been widely recognized as a popular

form of serious game in education and training. The following table summarizes the features of our VR game.

TABLE I. VR GAME FEATURES

Name	The voyage of “Gothenburg” to Canton
Genre	RPG game
Art style	Realistic painting style
Platform	Virtual reality device
Learning Objective	History of the “Gothenburg” and Canton

B. Game Design Model

To determine game elements that could fulfill the desired educational experience, we employ the Elemental Tetrad of Games framework as defined by Schell [14]. The Elemental Tetrad of Games is one of the most referred model, which has been widely acknowledged and accepted in both the academic research and the game industry. The Fig. 1 shows the roadmap of our game development.

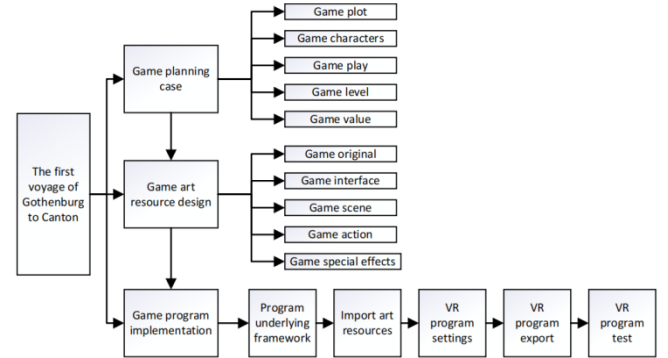


Fig. 1. The Roadmap of Game Development

Shell classified all game elements as four categories: mechanics, stories, aesthetics and technology. Mechanics are the rules and procedures of the game, describing in which way players can achieve the goal and what happens when they play. Stories are the sequence of events that take place in the game and make up a narrative background for the game world and player actions. Aesthetics are the most visible aspect of the game and describe how the game looks and sounds, such as graphics, sound and music. Technology is what makes the game work and limits what is possible for the game, such as the engine and hardware.

C. Game Design and Development

1) Game Mechanics

Game mechanics are the key elements that make games different from other forms of media because they determine the interactivity of games through the procedures and rules. As pointed out by previous researchers, for the design of educational games, the game element directly affected by the learning objectives is the mechanics. The concept of game mechanics was used here to understand and analyzed the main

game elements that allowed games to be effective at encouraging learning, as shown in Fig. 2.

Schell divided game mechanics into six subcategories: (1) Space; (2) Objects, attributes, and states; (3) Actions; (4) Rules; (5) Skill; and (6) Chance. Space is the game world where the game is played. Objects are things that players can manipulate in the game world, while attributes are categories of information of the objects and each attribute has a state. Actions define what players can do in the game. Rules describe goals of the game and consequences of actions. Skills are the abilities that players' character needed to complete the mission. Chance refers to randomness and uncertain events of the game.

TABLE II. VR GAME CONCEPT

Space	A VR game map that reproduced the Pearl River and the famous Whampoa port of Canton in 18th century.
Objects, attributes, states	Drive the ship of "Gothenburg" to the Naihai Temple of Huangpu port. The initial health value of each player's ship is 500 points and when the health value is 0, player will lose the game.
Action	Drive the boat across the Pearl River
Rules	Total score = 500 x (300 - seconds taken to complete the task) + 200 x life value when completing the task
Skill	Forward - drive the boat forward Escape - drive the ship to avoid obstacles
Chance	encountering obstacle and currents randomly

2) Game Stories

The story provides a framework for the game play and a justification or an excuse for the encountering challenge. In our game, players are provided with a background story telling them what they need to do in order to win the game.



Fig. 2 The East Indiaman Gotheborg in our VR game

As shown in Figure 1, the main storyline of the game is that a Swedish merchant ship "Gothenburg" came to Canton to trade at the 18th century, and it needed to complete a series of operations. This history is a part of the Maritime Silk Road that refers to the maritime trade channel between ancient China's coastal areas and the rest of the world to trade silk, tea, spices and other materials. At the same time, the teaching content can be integrated into the game story, explaining knowledges about the Maritime Silk Road in Qing Dynasty. The game designed a number of different historical land makers, such as Whampoa port, Thirteen Hongs, and Guangdong Customs, reproducing

the historical features of Guangzhou in the 18th century, as shown in Fig. 2 and 3.

3) Game Aesthetics

Aesthetic expression of has the most direct connection with player's experience. The visual aesthetics of our game was set in a realistic world created through 3D production technology to make the in game feeling more realistic and to increase immersion we included, as shown in Fig. 5. The game background music and sound effects were used when necessary.



Fig. 3 The Pazhou in our VR game

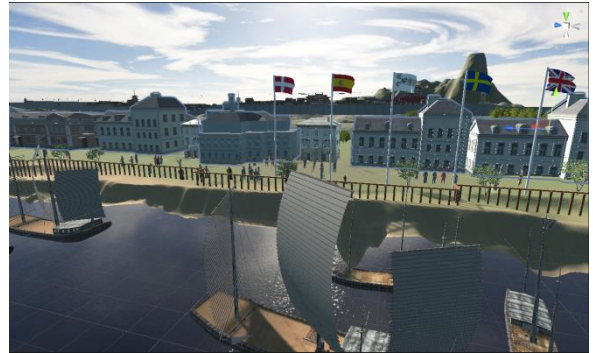


Fig. 4 The Thirteen Hongs in our VR game



Fig. 5 A screenshot of first-person perspective of the VR Game

4) Games Technology

The game was developed using the 3D Unity engine on a platform of HTC VIVE VR device as shown in Figure 6. The modeling software selected for this project was 3ds MAX and MAYA. Using the graphic processing technology of 3ds MAX, we built detailed realistic three-dimensional models and animations for the game. A real terrain system of the Pearl River and Canton was built using the Unity 3D, such as the terrain feature of rivers, hills, and plains, creating an immersive experience of the game world, as shown in Figure 7. For example, the parameters of the river system, including the wind

speed and the water flows, were tested and adjusted in the Unity 3D. And the game was released with an installation package through the Unity 3D development tool.

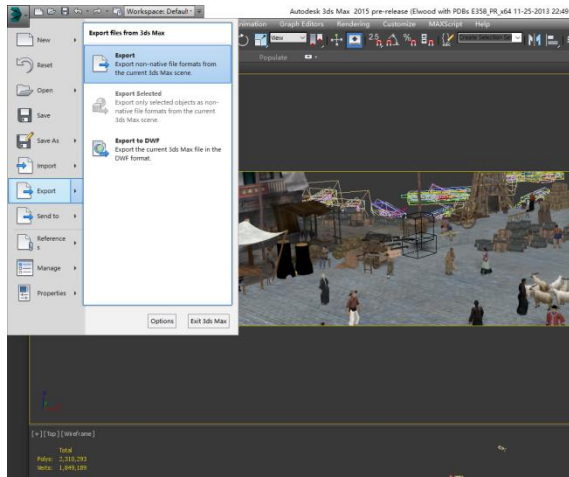


Fig. 6 Modeling with 3dsMAX

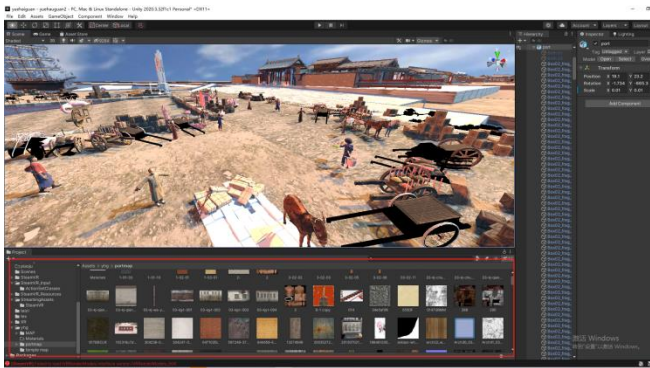


Fig. 7 Importing the model into Unity 3D

The other tools used here were the Ximerse Rhion-X virtual reality system and the supporting product development technology program (SDK).

III. DISCUSSION AND CONCLUSION

We proposed a novel approach for using VR games for cultural heritage learning scenarios. Our approach combines the advantages of action-based VR Games for learning, for which up to today exist a multitude of successful examples, with the advantages of experiential learning processes. The game includes scripted role-playing scenarios that can be completed through the effort and commitment of participant on a VR device. We demonstrated how game mechanics for cultural heritage education could be implemented in practice to create meaningful and engaging experience. The learning contents are integrated into the game-play and players have to complete a set of quests in order to make progress in the game. This study, the follow-up work integrating and customizing it for major cultural institutions or museums, will help to develop an interdisciplinary research community of cultural heritage education that spans in China [15]. This can occur through collaboration between the education institutions of cultural heritage to develop new media technology, cultivate talent, and provide support to the fledgling industries and new digital entertainment oriented incubation programs. Our research could

lead to an upgrading in the VR game development of China. This is still a fledgling industry that needs a lot of exploration, especially in the improvement of design practice. New research findings can inform the development of products and services offered by China's VR, game, education, and service industries.

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