

# A Virtual Informal Learning System for Cultural Heritage

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**Abstract**—Computer graphics and digital technologies have opened up a myriad of ways for both preservation and transfer of cultural heritage information. The digital storage systems, digital lab notebooks and virtual museums are all examples. VR technology development has made it possible to construct large virtual environment, and also provides immersive and interactive qualities to the cultural heritage content, thus the users could achieve learning outcome by plenty of interactions and immersions in the accurately represented digital reconstructions of cultural heritage which is no longer in existence. This paper presents a virtual informal learning system for the famous ancient painting of “Qingming Festival by the riverside”. Innovative multi-screen projection and interaction techniques are also presented.

**Keywords**—cultural heritage; informal learning; user immersion

## I. INTRODUCTION

Cultural heritage, as a universal treasure, has been handed down from generation to generation during the long human history. Most of them include rich learning information. Advanced development of computer graphics technologies and digital technologies support cultural heritage preservation and transmission in various approaches. It becomes an important way to preserve cultural heritage artworks by the digital processing techniques such as immersive VR system, image indexing and inpainting. A diverse range of cultural heritage preservations are using these techniques for heritage applications such as the technique of capturing texture by laser scan [1], virtual art shop [2] and involving intelligent person in to the virtual reality system [3]. Considerable amount of work pieces have been implemented with digital preserving [4] and on line exhibiting [5], [6] as well as virtual explorations [7]. They all had a lot to do with improving the steps of the world's heritage preservations.

Informal learning is a semi-structured ongoing process and independent from instructor leading programs. It usually occurs in a variety of places outside school, such as museums and exhibitions centers as well as while learning at home, working, visiting exhibitions and through their daily interactions with other people. A study of time-to-performance in the early 1990s shows about 75% of people's performance would achieve certain levels of informal learning outcome [8]. Perez

et al. proposed their opinions on the integrated level within heritage education [9]. They claimed that the approach to heritage is interdisciplinary and holistic. In terms of education, heritage is considered as objective content and specific resource, which is facilitating more comprehensive, meaningful and motivating vision of teaching. Heritage is based on constructivist principles, which were characterized by a social and investigative mode of education. Conceptual, procedural and attitudinal contents are fully integrated in the cultural heritage education. The ultimate aim of heritage education tends to be the development of critical thinking ability, and the appreciation and conservation of heritage as something which confers identity.

Adopting informal learning theory in a cultural heritage museum is important, because it seamlessly matches education and entertainment, and brings a new era for museums by enhancing its immersion, visualization and preference. The advanced technology such as the virtual and augment reality techniques, interactive manner, and story-telling approach are to make the learning process effective and enjoyable. Creating fully immersive 3D virtual environment presents the users with new approaches of informal learning by experiencing and interacting with the cultural heritage in a different setting. Immersion is the subjective impression that one is participating in a comprehensive, realistic experience [10]. Immersion in a digital experience involves the willing suspension of disbelief, and the design of immersive learning experiences that induce this disbelief draws on sensory, behavioral, and symbolic factors [11]. Previous research on immersion has been scattered in several different areas such as virtual reality, game research, interface design and so forth. Virtual reality research has an interesting perspective on immersive experience. Studies have shown that immersion in the virtual environment can enhance education in at least three ways: by allowing multiple perspectives, situated learning, and transfer. Dede concluded that immersion could foster learning experiences and draw on a powerful pedagogy through multiple perspectives, and lower degree of immersion can still provide situated learning [12]. Patrick et al. proposed the concept of presence as the extent to which a person's cognitive and perceptual systems are tricked into believing they are somewhere other than their physical location [13].

The aim of this study was to implement a virtual informal learning system for cultural heritage by natural user interaction. We approached the system design in two respects, one is how to manage the multi-screen projection, and the other one is how to implement the user interactions with virtual characters efficiently by their implicit relationship. This paper is organized as follows. In section 2, we introduce the design and development of the informal learning system followed by section 3, which describes the implementation and early results of the system. The conclusion and future work are given in section 4.

## II. SYSTEM DESIGN AND DEVELOPMENT

The main sections for the system design include the content organizing, basic 2D impainting and 3D modeling, animation creating for both of the virtual environment and virtual character, multi-screen projection, and the development of the virtual character and gesture interactions with the system. The following describes each section in more detail.

### A. Qingming Festival by The Riverside

The famous ancient painting, “Qingming Festival by the riverside”, which was painted by Zhang Zeduan in Northern Song dynasty about 1000 years ago, is a rare realistic artwork and considered as a world-class cultural relic. As one of the most important traditional Chinese festivals, Qingming Festival is granted an intangible cultural heritage. It has a long history of about more than two thousand years, and was called March Festival in old times as well. People celebrate it with various actions, such as commemorating ancestors, spring outing, swinging and planting trees etc.

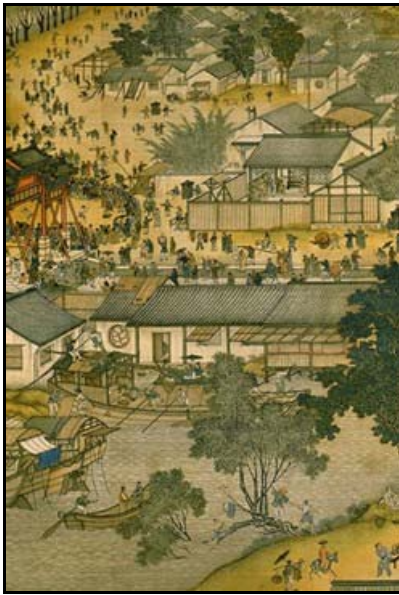


Figure 1. Part of the painting of “Qingming Festival by the riverside”.

The painting shows the prospering scene around Qingming Festival in Bianliang City, and covers dozens of miles along a river including more than 500 human figures, 60 animals, 100 trees, 30 buildings and pavilions, 20 wooden boats and many other characters. It gives the audiences a bird’s eye view of the

flourishing scene of Bianliang city which was the capital of Song dynasty. It was completed from a panoramic view and with detail scenes along a river that stretched for dozens of miles. The origin version of this painting, which is about 500 centimeters long and 25 centimeters wide, is kept in the National Palace Museum in Peking, China. One part of this painting is showed in Fig. 1. The task of this system is to exhibit the famous Chinese painting on a large display wall dynamically and provide the users with natural interactions with the virtual characters.

### B. Image-based Animation

We use a method to show locomotive 3D objects on a 2D background picture. It makes the scene more alive. It can also improve the real-time rendering speed effectively. And with the purpose of combining 3D objects with 2D background harmoniously, we created the textures, lights and shadows as well.

We extracted certain 2D objects from the background picture and animated them. When the objects are solid ones, we just transfer and rotate them in terms of requirements. If the objects are characters which include humans and animals, the skeleton-based character animation method is used to drive them. In order to move the viewpoints when the animation is going on, TIP techniques [14] is adopted to create spidery meshes. The background painting with panoramic view is repainted and the perspective relationship is kept at the same time, so the spidery meshes can be generated easily. Fig. 2 demonstrates a 3D walking carriage in harmony with the background environment.



Figure 2. The walking carriage in harmony with the background.

### C. Multi-screen Projection

The main purpose of the system is to implement a real time informal learning approach to experience Qingming Festival by dynamically interacting with the virtual character and also have a virtual navigation in the famous ancient Chinese painting on a large display wall which is used as a big screen [15]. In order to display this large Chinese painting dynamically and keep artistic appeal, we did a multi-screen projection system for the Grand Canal Museum. The museum arranged specially a huge hall for this system. In the hall, there is a very large wall with 6 meters high and 12 meters long, which is used as a large screen. We designed a multi-screen based projection system in terms of the size of the wall. The surface of this wall is specially treated so that it can give good diffuse reflection. Therefore a PC-based multi-channel VR projection system is

employed in order to project a high resolution storytelling video on the large display wall.

The painting, “Qingming Festival by the riverside”, is repainted by artists and then is projected on the large screen. The music and commentary are played synchronously as the video goes on so that the flourishing scene of the capital of Song Dynasty shows vividly before us. It keeps well the artistic appeal of the painting, and shows us the flourishing scene of the capital of Song Dynasty as if we are standing right in the street. With the purpose of achieving fully user immersion, we developed the system further more in an interactive facet that the users control virtual characters and also have real time navigation by gesture interactions.

C/S architecture was used in this projection system. The video is played and every frame is segmented into 30 tiles in the PC server. Then each segment is transmitted to the corresponding client PC through switch synchronously. Each client connected with a projector is responsible for rendering one tile and projecting this tile to the proper position on the large wall. The architecture of projection system used in the system is shown in Fig. 3.

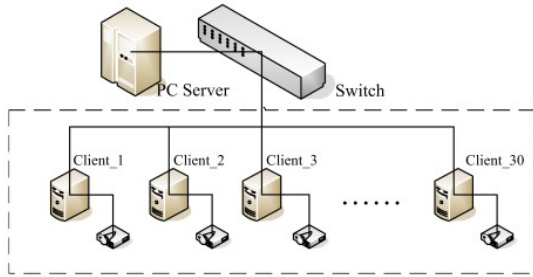


Figure 3. The projection system architecture.

#### D. Personalized 3D Avatar Creation

We employed an avatar-based interaction to enhance the immersive feeling of the users and connect the users and virtual environment. The avatars can be customized in order to enhance the realistic behavior of the users. Recently, personalization has become a novel topic because of its ability to provide a better user experience in the era of virtual reality. Studies reported that personalization positively impacts human-computer relationships [16]. However, existing studies about personalization have largely focused on the parameters setting for users’ custom. This system integrated personalization with an avatar construction. The users can manipulate an avatar of their own face. We employed a photo to reconstruct the user’s 3D face model and implement the customized avatar. The application method is shown in Fig. 4. There are two steps: first, extracting the characteristics of the user from his photo; second, reconstructing face model according to extracted characteristics.

#### E. Gesture-based Interaction

We proposed a robust real-time hand tracking and hand posture recognition method. It allows the user to communicate with their customized avatar. At the same time, the users could also interact with the constructions in the system and observe

the specific models as well as navigate in the system by gestures. We firstly detect the specific posture using a multi-cue method based on modified census transform, in order to trigger hand tracking and hand posture recognition. It’s based on velocity weighted features and color cue, and applied to track the hand robustly with a single camera from the complex background. The method could also deal with large space with the objects of skin color due to its high detection rate. It is used to detect hand to trigger the system in the first frame. Then the hand is accurately segmented using both Bayesian skin-color model and the hand tracking result. Finally we use a novel method based on density distribution feature to recognize hand posture (Fig. 5). This method enforces the robustness of hand posture recognition because of its scale-invariance and rotation-invariance. The users can control the direction and manipulate their navigation in the system with their gestures (Fig. 6). The users are provided with much more natural interactions which help them enhancing their immersion in the virtual informal learning system.

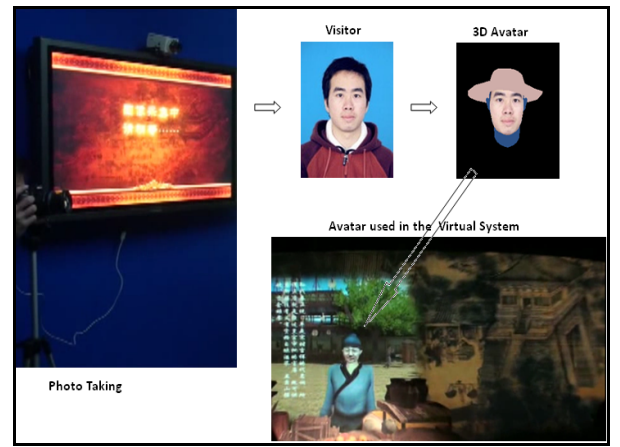


Figure 4. The application method to personalize a 3D avatar.

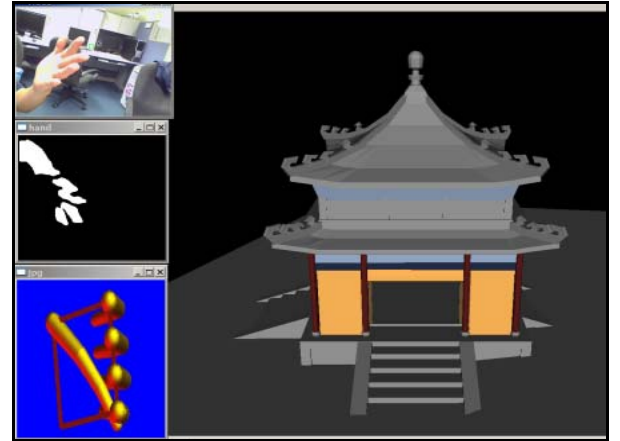


Figure 5. Real time hand tracking and hand posture recognition method.

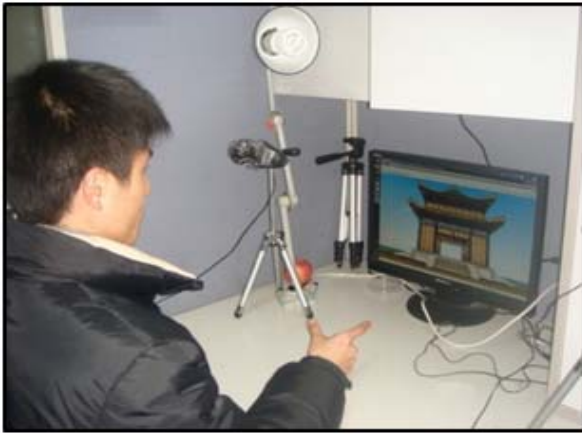


Figure 6. The users can observe the objects, change the viewpoint and navigate through the constructions by gestures.

### III. RESULTS

We extended this work for the Shanghai World Expo with the cooperation of The Crystal Company in Shanghai. The visitors interact with the painting by waving their hands at the avatar in the system, and the avatar will be able to respond to the users by the tracking technology. Since we create 3D virtual scenes from the 2D painting, the users can interact with virtual objects or characters. It can also improve the interaction between avatar and the virtual world by giving those objects in the environment with semantic information.

Adopting virtual characters generally has two main functions: first, the virtual characters can gain the publicity effect because their lovely appearance can draw huge attractions from the audience and bring the public recognition to the system; second, the virtual characters can make the user gain authentic experience. Additionally we integrate the avatar personalization idea in the system, which is different from the traditional interactive methods. By the photo-based 3D face model construction method, the avatar can be customized to enhance the realistic behavior of either virtual human or the users. It provides better immersive experience in virtual environment and positively impact human-computer interactions.

### IV. CONCLUSIONS AND FUTURE WORK

We represented both the historical culture environment and human figures in the system accompanying with plenty of interactions. We rebuilt the constructions, shipping, water transportation tools, horses and human figures, and digitally repainted the background, and then constituted an interactive environment by joining all the space, objects and colors together. Additionally, a multi-screen projection and adaptive virtual character were applied to the system. This paper probes into these immersion impacts in virtual informal learning of cultural heritage to enhancing the system usability. As we've implemented and evaluated the system, we learnt things that can be applied to the development of future work. It includes: how much immersion is enough for learning cultural heritage,

how to design the system in terms of different respects which are supporting cultural heritage virtual informal learning? In other words, how can this immersion be operated, and how to enhance the immersion efficiently?

### ACKNOWLEDGMENT

Project supported by China 863 Project (Grant No. 2009AA062704 and 2007AA10Z224-1), and the Open Project of Beihang University's State Key Lab of Virtual Reality and System. The authors would like to acknowledge Zi Li, Kangde Guo and the support from colleagues of the project group for their contributions.

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