Cultural Heritage as Digital Experience: A Singaporean Perspective

Wolfgang Müller-Wittig, Chao Zhu, and Gerrit Voss

Centre for Advanced Media Technology (CAMTech)
Nanyang Technological University (NTU)
50 Nanyang Avenue
Singapore 649812
wmw@camtech.ntu.edu.sg

Abstract. Interactive 3D computer graphics technology is now extremely popular, seen in the increasing interest in and use of 3D digitization of cultural heritage contents. This paper introduces a digital interactive cultural heritage system which embeds Virtual-Reality (VR) technology within the Peranakan culture, the Peranakan culture being a Singaporean unique ethnic culture. A prototype has undergone the full developmental process of being implemented, tested, and evaluated. This paper will also discuss the results of the usability test.

1 Introduction

In Singapore, CAMTech are the first to implement the use of VR technology as an effective medium of disseminating Peranakan culture. Such work mirrors the use of computer graphics technology to open up new dimensions in varied fields such as archaeology, the arts, tourism, and education. For example, similar efforts are evident in projects ranging from China's Du Huang Cave [1] to DentroTrento in Italy [2].

Background to the Peranakans. This community, also known as the StraitsChinese, is descendants of an early Chinese community that settled in what was known as the Malay Archipelago. Their origins date back to at least the 17th century [3], and thus they represent among the oldest historical ethnic communities in Singapore. They possess distinct clothing, cuisine, architecture, and even an individual linguistic system [7]. They combine a Chinese and Malay way of life, and today, with assimilation of certain western cultural elements, form a unique ethnic group, outstanding even against Singapore's multicultural backdrop. In Singapore, Peranakans play the important role of being an influence upon various aspects of Singapore life, for example, its economy, arts, and culture. Intense urbanization and western acculturation has, however, sadly eroded interest in the Peranakans. The young generations in particular, are definitely more interested in technology and its gadgetry rather than history or culture. The question of the preservation and perpetuation of the culture has thus become critical.

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CAMTech is an advanced media technology media provider, so it was inevitable that we respond to the challenge of assisting the Peranakan community with its problem, which has resulted in our project to infuse the Peranakan cultural heritage with VR technology, or *virtual heritage*. Section Two provides the rationale for the choice of VR technology.

2 Challenges and Solutions

Three challenges encountered in this domain of Virtual Heritage are:

- 3D documentation
- 3D representation
- 3D dissemination [4].

3D documentation. 3D documentation is the process of capturing and managing cultural heritage data, or information about the subject. It is impossible to present all the various manifestations of culture in one frame. Thus the first challenge is selecting what might be the most representative image of that culture. With the Peranakans, we decided to digitally construct Peranakan Shophouses. We made this choice after reviewing the literature, investigating related materials, such as photographs, books, including visits to the local museums, and interviewing Peranakans themselves, as well as experts in their history.

The Peranakan shophouses are typical terrace row houses, normally lengthy and narrow, possessing a distinct five-foot walkway in the front. The architecture is highly artistic, vibrant with color and details which reflect the Chinese and Malay heritage. Combined with an intricate interior design, the shophouses make for an ideal 3D museum.

3D representation. The second challenge is to capture and record the 3D data as realistically as possible. This is achieved by using authentic materials, for example, the use of photographs, which are scanned to be used as referencing images or textures for 3D modeling.

The most common method of 3D presentation is 3D modeling and visualization. High quality 3D models are essential to create an impressive and attractive visual. An effective and efficient visualization system is also required to support the rendering of large amounts of 3D modeling.

In this project, we managed to accomplish more than the elaborate modeling of the Peranakan shophouses. We have also established a photo-realistic 3D object library which has around 60 items, including furniture, ceramics, embroidery, silverware and various accessories. These are also accompanied by introductory notes. To enhance and augment the realism of the images, pre-lighting technology is employed to simulate day light effects and shadows.

Figure 1 below shows the rendering images of the 3D models of the interior and façade of the shophouses. The 3D models are visualized using our in-house interactive visualization system. This is which can handle massive 3D data processing.

Fig. 1. Interior and façade of the shophouses

3D dissemination. 3D dissemination refers to the environment conveyed to users. The most important advantage of a 3D digital culture heritage is that it is an easier, cheaper and safer platform, through which users can access and experience cultural treasures. The growing attention to the importance of culture, be it for education or tourism objectives, has brought about a need for culture to be conveyed in both educational and entertainment formats. It is a widely acknowledged and popular educational principle that learning should be lively achieves all this. It provides immersive experiences as well as real-time interactivity. It can be designed for applications for an individual user or small groups.

Our hardware is back project technology. We have also been researching and exploring for even more avenues to increase interactivity, one of them being the use of a virtual avatar as tour guide, as well as a Chinese calligraphy brush.

3 Prototype Development and Implementation

3.1 Software System Design

As illustrated in Figure 2 below, the whole system is a layered structure. At the base is the OpenGL library, a mere graphics mechanism which actually knows nothing about the scene structure.

On top of this is the OpenSG library, a scene-graph based real-time rendering system [5]. The advantage of using OpenSG is that it is a Multi-Platform Open Source system which can handle a cluster as well as multithreaded data structures both easily and efficiently, and also capable of being used in various other ways [5]. Our in-house VR system is an extension of the OpenSG library. We call it *VSC Library* because it inherits all the merits of OpenSG but is more application-oriented, and can be customized to different projects.

With this Peranakan project, a *Digital Heritage (DH) Project Library* has been created on the top of the VSC Library. This library includes three main components: scene control nodes, visualization control nodes, and interaction control nodes.

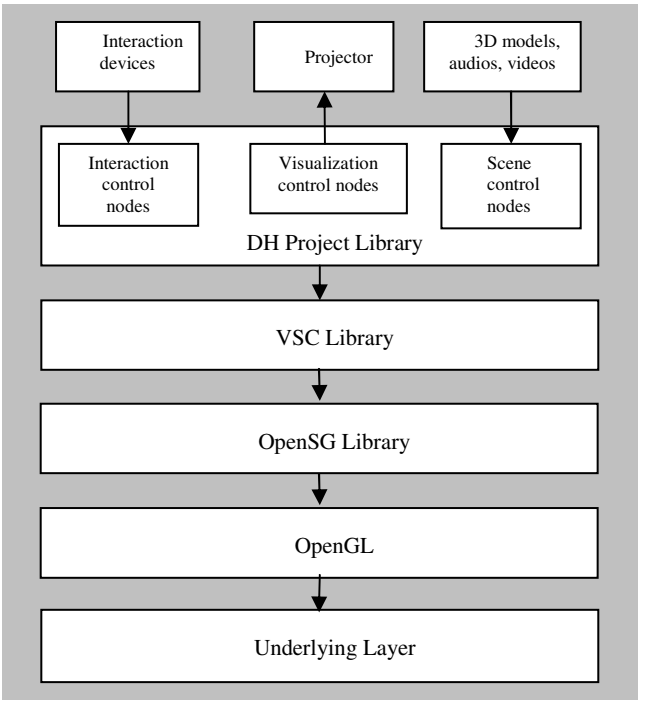

Fig. 2. Software system design

The **scene control nodes** load the 3D models and related media files, such as documents, images, audios and videos, into the system. The **visualization control** nodes adjust the visualization hardware, for example, they can control stereoscopic display. The **interaction control** nodes link all the interaction hardware devices. In this project, the device is the Chinese calligraphy brush attached with sensors.

The advantage of this layered structure is its high flexibility and modulation. Especially since the top level controls are designed by using scripting languages, the design of the interaction contents is much easier for programmers and artists who have less knowledge about OpenSG, OpenGL, or other underlying issues. Our paper now focuses on our interaction tools, the *Virtual Tour Guide* and the *Chinese Calligraphy Brush*.

3.2 Virtual Tour Guide

Tour guides are commonly used to give information about a heritage or tourism site. Also in use would be information displays or audio broadcasting. Digital heritage sites would thus use virtual tour guides.

Our virtual tour guide is a Chinese-looking male wearing traditional Peranakan clothing as befits the Peranakan background [7]. Besides modeling and texturing by referencing real images, a series of animated body movements and facial expressions is also given him. He can walk, talk, and respond to user requests. For example, he

can be called up to lead users to the import exhibits, and then introduce appropriate information.

The modeling and animation uses commercial 3D software, in our case, *Autodesk Maya* [6]. Despite the massive amount of work put in, there is still plenty of room to create even more convincingly realistic images. We are also working on making the avatar appear more natural, fluid in its movements, as well as working on the quality of its responses. One possibility is to add a path-finding function to the virtual tour guide, should users want to visit the house at their leisure, or own pace, rather than having to adhere to the pre-defined avatar-led path.

3.3 Chinese Calligraphy Brush

The Chinese calligraphy brush has a long history in Chinese and Asian culture. It was chosen as the major interactive device, being intuitive and easy-to-use, possessing a kind of human-human interface. But when this kind of communication mode is brought to computer-human interaction, it becomes possible to make the computer react to what human beings want to express with the brush.

The "brush" has two functions, one to write commands, another to navigate. It is thus more flexible than traditional writing tools.

The 'writing' function performs like traditional calligraphy brushes. Some simple Chinese characters are chosen as the command words that control the navigation as well as the information display. The brush is connected with tracking sensors. When users imprint any strokes on a blank writing board, the combination of the strokes is recorded and recognized by the underlying pattern recognition algorithm. For example, when a user writes the Chinese character *up*' which is composed of three strokes, the system will guide the user to level two of the shophouse. Non-Chinese speaking users can call the virtual tour guide to help them write the characters. The execution of this function is highly dependent on the accuracy of the pattern recognition algorithm. Our pilot test shows most users, especially non-Chinese speakers, have difficulty writing the characters in a standard way. The difference between handwriting makes the recognition process even harder. However, despites difficulties, most users enjoy this innovative and fun way of learning through experience. Figure 3 below illustrates.

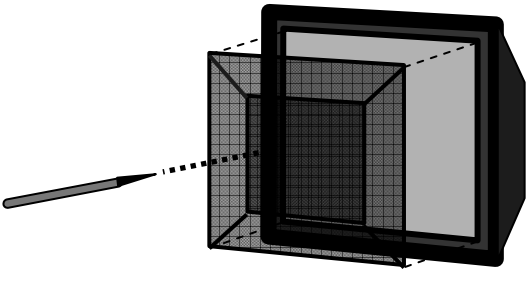

Fig. 3. Navigation with brush

To maintain consistency between functions, we also explored how to navigate in the virtual scenario using the calligraphy brush. The position and orientation of the brush is traced by the tracking system, so it is possible to connect the movements of the brush with the Graphics User Interface (GUI) on top of the scenario display. For example, the foreground of the GUI is divided into five zones as shown in Figure 3. When the brush 'points' at the up zone, the user will move forward in the virtual world. Similarly, the bottom, left and right zones activate backward, left and right movements respectively. A touch of the middle zone will stop all navigation and users can then look at the exhibits, 'clicking' with the brush on either menus or information panels for further action. During the implementation stage, a question raised was whether the calligraphy brush really enhanced navigation experiences, more than traditional VR navigation devices. A usability test was conducted to explore this question.

4 Usability Test

A test bed was created to study user preferences and adaptability towards different navigational mediums in a virtual environment, in this case, the usage of a Chinese calligraphy brush against the usage of a 3D spacemouse in the virtual shophouse environment.

4.1 Setup of the Test bed

The virtual heritage environment was set up with a single double storey shophouse block and a static avatar. A short introduction and instructions on the two navigational tools were given to each tester to better their understanding, after which, they performed short navigation trials on each of the devices to familiarize handling. See Figure 4 below.

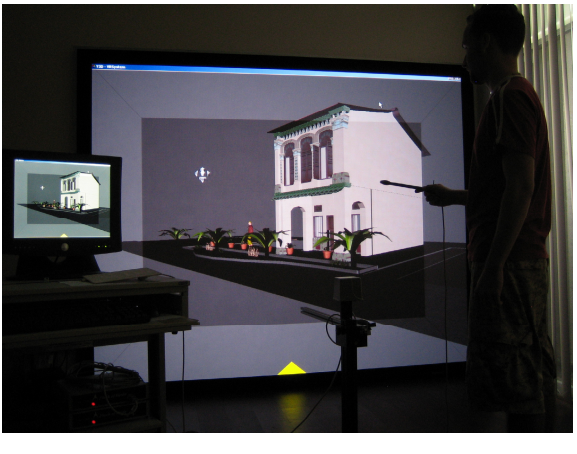

Fig. 4. Usability test setup

Testers were assigned 3 tasks (in order of ascending difficulty) to undertake during each usability test [7]:

1. Stand in front of the Virtual Tour Guide.
2. Walk around the shophouse and come back to the Virtual Tour Guide and stop.
3. Walk into the shophouse then walk out of the shophouse using the five-foot walkway.

The first task aimed at warming up testers in the virtual environment by instructing them to take a simple one directional route from the default start position to a specific location in front of the avatar. The second task aimed to test the orientation control of each tester with a route that required changes in direction during navigation. This test also studied how reaction varies between usage of the calligraphy brush and spacemouse, in terms of adaptability and ease of movement. The last task aimed to test a more delicate degree of navigational control. Each tester was requested to complete a questionnaire based on their virtual experience.

4.2 User Statistics

The study used 26 testers consisting of NTU staff and students (Males: 80%; Females: 20%). Most of them were between 25-30 years of age. It is important to note that a little more than half the group had prior experience navigating in a virtual environment.

5 Results

The questionnaire consisted of 16 questions, which every tester had to complete after their entire test round. 80% of the group found usage of the Chinese calligraphy brush as a navigational tool innovating and interesting. It took most testers less than three minutes to become familiar with this interface. Many found the spacemouse interface harder to control, with a longer familiarization period required. Thus testers ranked the 3D spacemouse ‘difficult’, with many taking three to five minutes getting used to it. 75% testers felt it was easier to navigate with the calligraphy brush. The calligraphy brush enhanced virtual experience for at least 50% of the group. Table 1 lists some of the results after analyzing the questionnaires [7].

The biggest limitation to the current calligraphy brush interaction was the limited degrees of freedom in navigation (i.e. left, right, up, down and centre) and the speed of travel. Many preferred a wider navigation and speed range. But then testers found the 3D spacemouse too sensitive. They reported “spinning” out of their orientation path and getting lost and confused within the environment.

Generally, testers were very positive towards showcasing cultural heritage in a virtual reality environment and the usage of props for interaction. Many felt that VR is a great way to preserve cultural heritage and allows for more information Most also agreed that the introduction of interactive devices was a good idea and served to enhance their VR experience.

Table 1. Some questionnaire statistics

What do you think of using a Chinese Calligraphy brush as a writing and navigational tool?		
Quite innovative		79.2% (19)
Not a good idea		16.7% (4)
Was it easier to navigate with the 3D spacemouse or with the Chinese Calligraphy brush?		
3D spacemouse		25.0% (6)
Chinese Calligraphy Brush		75.0% (18)
Do you think the Chinese Calligraphy brush enhances the Virtual Heritage experience compared to a conventional spacemouse?		
Yes		50.0% (12)
No		41.7% (10)
How long did it take you to get familiar to using the Chinese Calligraphy Brush?		
Less than 3 minutes		79.2% (19)
Less than 5 minutes		16.7% (4)
More than 5 minutes		4.2% (1)
Do you think props such as flashlights or Chinese Calligraphy Brush should be used according to the specific Virtual Environment?		
Yes, props should be used		75.0% (18)
No, conventional mouse is OK		20.8% (5)

6 Conclusions and Future Work

We are confident that our idea of educating persons about an unique Singaporean cultural heritage using VR technology with the Virtual Tour Guide and the Chinese calligraphy brush are definitely innovative user interfaces. The usability test indicates that users are generally interested in experiencing traditional cultural contents in a high-tech environment. Innovative interactivity is the key.

To improve the interactivity of our user interface, further work needs to be carried out. More usability tests will be set up to statistically analyze the difficulties of the writing function of the brush interface. We will also work on the Virtual Tour Guide's

modeling and animation so that it becomes even more life-like. Adding Artificial Intelligence (AI) or other game elements can also make the interface more user-friendly and entertaining.

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