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Digital Heritage Application as an Edutainment Tool

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Abstract

With the fast-growing technological advancements in Virtual Reality (VR) technology and easier access to more affordable computer graphics hardware, it has become possible to create a diverse range of VR applications that are not only geared towards scientific researeh and medieal training applications but also for "edutainment" purposes for the general public. "Edutainment" is an upcoming field that combines education with entertainment aspects thus enhancing the learning environment to be much more engaging and fun-filled. In this paper, we describe a projeet on a Digital Heritage applieation aimed to serve as an edutainment tool. The visitors are able to virtually "enter and explore" the reeonstructed heritage environment and learn more on the presented content through virtual experiences. We have incorporated a Virtual Tour Guide that presents the cultural and historical content through non-linear digital storytelling techniques for the dynamic content creation to fit the changing profiles and needs of the visiting audienee.

CR Categories: I.3.6 [Computer Graphics]: Methodology and Teehniques - Interaction techniques; I.3.7 [Computer Graphics]: Three-Dimensional Graphics and Realism - Animation and Virtual Reality; I.2.4 [Artificial Intelligence]: Knowledge Representation Formalisms and Methods - Semantic networks

Keywords: Digital Heritage, Non-linear Storytelling, Virtual Tour Guide, Virtual Reality

1 Introduction

Interactive storytelling techniques coupled with Virtual Environments (VE) provide the visitors a ehance to explore the VE through an interactive seene. In an interactive seene, the virtual object the visitor interacts with has the ability to dynamically respond to the needs and profiles of the specific visitor/user. The content that is presented is highly customizable in the sense that the visitor's profiles and the specific needs are considered in the content creation every time certain information is presented.

In our application, we have incorporated interactive storytelling techniques to a Digital Heritage application. Our main goal is to present historical and cultural content of the reconstructed 3D VE to the general public in a pedagogical and entertaining way. We believe interaetive storytelling techniques can enrich the process of exploring the VE since eaeh visitor can walk away with a different virtual experience. The reason we have chosen to develop a Digital Heritage applieation is because presently, there is a need to preserve heritage sites in new and innovative ways. Heritage sites are being destroyed to many factors including urbanization, negleet, pollution, and even tourism and new ways to conserve, preserve, and interpret cultural and natural history need to be employed. Many heritage sites are being reconstructed through VR technologies ranging from digital arehives, archaeology, arehitecture, museum installations, augmented reality and VR, virtual GIS, to 3D image reconstruction. Most importantly, VR teehnology presents new and innovative ways to experience and interact with the reeonstructed cultural heritage sites with many new possibilities.

In this paper, we present a framework for developing a Digital Heritage application. As part of the intuitive interaction, we have incorporated a Virtual Tour Guide who guides the visitors around the VE and presents eustomized content.

This paper is organized as follows. In Chapter 2, we present the coneept of our application and in Chapter 3, we present our framework and a detailed view into the different sections of the framework. Finally in Chapter 4, we eonclude and present future work.

2 Concept

Creating compelling stories that can constantly engage the visitor's attention and participation in Virtual Environments is a challenge. In order to ereate a fully immersive and interactive Digital Heritage environment that can capture the visitor's attention throughout the entire virtual experience, we need to not only create compelling and realistic 3D models of the heritage objects, we also need to present the content in captivating ways. This is wherc the interactive storytelling comes in.

Interactive storytelling is a form of non-linear storytelling. Non-linear storytelling techniques differ from the traditional linear storytelling techniques in that in a linear story, the story begins at one end and gocs through a pre-defined sequence and ends at the other end. In non-linear stories, the story consists of a graph of multiple story "nodes" where each "node" is connected to one or more other "nodes". [Parise]. The connections between thesc "nodcs" represent possible directions the story might take

and the branching from one "node" to the next can be either being random or be based on some sort of division system.

Cavazza [2001] presents the different approaches to interactive storytelling that differ by the respective emphasis on the various aspects of the storytelling such as emphasis on the user [Cavazza et al. 2001, Perlin and Goldberg 1995], the plot [Sgouros et al. 1996], or the artificial characters [Mateas 1997]. In our paper, we have put the emphasis on the user through the implementation of User Modeling achieved through tracking each user and creating a unique profile for each user. Here, the users are modelled by using the concept of stereotypes. Each user has a user profile that describes, among others, interests, the state of knowledge, methods for presenting information, age, gender, place of residence, and time. This profile allows for the presentation of information relevant to the user. For example, if the user is young, the same information can be presented in a more game-like way according to the user model that has been created for that specific user.
Information on the different users and all the possible exhibits are stored in a database in the system. The information on the exhibits is represented as a weighted graph of interconnected exhibits where they are actually the different "nodes" of the graph. In the weighted graph, each of the nodes has a different prioritization which is constantly changing and set according to the profile of the visitor. Each exhibit is selected based on the user's interests and needs thus this network of interconnected exhibits allows for the dynamic creation of stories unique for each visitor. Section 3.2.3 describes the non-linear storytelling technique in detail.

3 Framework

Figure 1 shows the overall framework for the Digital Heritage application. It is divided into Content Creation and Content Presentation. Content Creation component is the process of gathering information and generating a reusable library of realistic 3D models for the Digital Heritage scenario. All the heritage objects as well as the Virtual Tour Guide are created in this component. Additional information that is shown to the visitors are also created and stored in a database. The Content Presentation component is responsible for displaying the content to the visitors in a pedagogical and engaging manner. To achieve this goal, we have implemented a Chinese Calligraphy brush into the system as a user interaction device to aid the users in navigating around the scenario and executing commands to the Virtual Tour Guide. Non-linear storytelling techniques are incorporated in this component by tracking the visitors and creating the User Models. The following sections will describe the components in greater detail.

3.1 Content Creation

Interesting content selection in any Digital Heritage application is the core of the application. The heritage content has to be rich and abundant not only historically but also culturally, it has to be able to capture the curiosities of the general public and encourage them to come back for more. Being situated in Singapore, it was quite easy for us to select the rich culture of the Peranakans as the heritage content local to Singapore and its region. Peranakans are an important part in the history of Singapore. They are descendants of an early Chinese community that settled in the Malay Archipelago since the 17th century. Peranakans evolved as a result of intermarriages between these early Chinese settlers and the Malay. This unique community developed distinct customs, cuisine and even their own language, as they blended Chinese and Malay ways of life to form a new and rich culture.
The 3D models that have been created can be broadly categorized into dynamic models and static models.

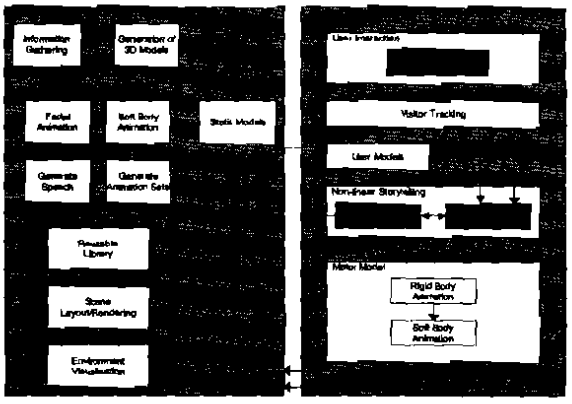

Figure 1: Overall Framework

3.1.2 Virtual Tour Guide

The Virtual Tour Guide that has been modelled is of Chinese ethnicity and dressed in traditional Peranakan clothing to fit the Peranakan profile. For the face modelling, a base face was created using NURBS modelling techniques and from this base head, viseme face sets were derived. Visemes are the mouth positions/shapes of a particular sound in speech. The base head uses these different visemes as targets to 'morph' between the different mouth shapes according to the analyzed sound files.
The body of the Virtual Tour Guide was modelled using subdivision surface modelling techniques and then mapped with a base hierarchical skeleton in order to generate animation sets. The Virtual Tour Guide will have in its library a set of pre-spoken speech for the cultural and heritage content he will present to the visitors and a set of basic locomotion such as walking and climbing up the stairs.

3.1.3 Cultural Objects

The Peranakans have a rich material culture in a variety of areas such as ceramics, furniture, and embroidery and silverware. High-quality textures were used to present these 3D models in the object library. An extensive library of Peranakan objects are currently being built and these objects are capable of fast real-time rendering. For data acquisition, we have gathered information on the Peranakan material culture by visiting Peranakan museums exhibits, through specialized books on the Straits-Chinese, and through actual heritage site visits. Figure 2 shows the Virtual Tour Guide and a Peranakan hall.

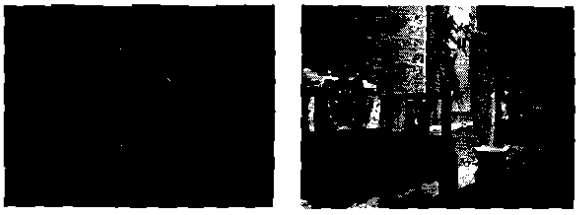

Figure 2: Virtual Tour Guide and Peranakan Hall

3.2 Content Presentation

The content that has been created, including the 3D models of the exhibits, video sequences, images, and text spoken by the Virtual Tour Guide, is presented to the visitor in real-time. Visitors can walk through and explore the virtual rooms much like in a real museum. They can also request for more information on the exhibits from the Virtual Tour Guide. However, rather than duplicating the passivity of a museum, our goal is a system that is capable of learning the preferences and interests of the visitors and to show them the specific content they are interested in directly. This is achieved through visitor tracking and nonlinear storytelling techniques. Visitor tracking gathers information from the visitor that indicates the content she/he is interested in. The storytelling uses this information to learn about the visitor, select the right content, and compose a story out of small information chunks.

3.2.1 User Interaction

Visitors can interact with the system in various ways. They can navigate and walk through the virtual rooms and explore the exhibits inside them at their own pace. They can also select exhibits they are interested in to get more information. Visitors can also interact with the Virtual Tour Guide. They can call him whenever they need to ask him questions that they select from menus. Visitors can also follow the tour guide and take part in an interactive tour, stop the tour whenever they wish, and continue it later.

We utilize an interaction method that is easy to use, correlates with the content of the Digital Heritage application, and increases its edutainment value. Such interaction methods have been used in other Digital Heritage applications. An example is the Dunhuang Art Cave where a flashlight is used [Lutz and Weintke 1999]. We are using a Chinese Calligraphy brush as an interaction device. Calligraphy is an art dating back to the earliest day of history and a very familiar tool to the Asian culture. The visitor holds the calligraphy brush in one hand and a small drawing board in the other. She/he can use the brush either to write Chinese characters and symbols on the board or to point with it at the screen in order to navigate and select exhibits and menu items. The Virtual Tour Guide introduces new visitors to the usage of the brush and board and explains Chinese characters that the system understands. A tracking system is used to detect the position and orientation of the brush and board. A simple ray test shows whether the visitor points with the brush at the screen or writes on the board. The ray originates at the position of the brush and runs through its handle and tip. The navigation is restricted to walking on the ground. The visitor turns to the left or right when she/he points at the appropriate side of the screen and moves forwards and backwards when she/he points at the top or bottom of the screen, respectively.

Chinese characters can be written on the drawing board to execute commands. An example is the Chinese character "Ren" which means "Person". It is used to call the Virtual Tour Guide. All Chinese characters consist of strokes that have to be written in a specific order. We utilize an online Chinese character recognition that analyses the strokes while the visitor writes them. Afterwards it looks up the Chinese character that matches the recognized stroke sequence. Examples for recognition methods based on the detection of strokes can be found in [Amin and Sum 1993] and [Calhoun at al. 2002]. We only use Chinese characters that consist of a few strokes and hence are easy to memorize and can be written quickly. The character "Ren" for example only consists of two strokes. These characters are also suitable for visitors with no command of written or spoken Chinese. These visitors can gain their first experiences in writing Chinese which makes the interaction device itself a part of the culture to be explored.

Figure 3: Calligraphy Brush Interaction

3.2.2 Visitor Tracking and Visitor Profiles

In order to create a personalized tour with content that is interesting to the current visitor, the Virtual Tour Guide has to know who the visitor is and track his/her behaviour. Each new visitor is asked to fill out a short survey. If she/he is willing to complete it, the Virtual Tour Guide creates a profile from the obtained information such as age, gender, and place of residence. Besides this basic data, the Virtual Tour Guide constantly tracks the behaviour of the visitor. Tracking the way the visitor moves around and interacts within the virtual scene can provide information that shows if the visitor is bored, exited, or interested in a particular exhibit. The three most important parameters to track are Object Holding Power, Attention, and Request. The Object Holding Power as defined by Serrell [1997] is the time that a user spends in front of an exhibit. The Virtual Tour Guide assumes that the longer the time, the more interested the visitor is. The second parameter that is tracked is the attention that the visitor gives to the Virtual Tour Guide by following his recommendations. If a visitor follows a recommendation it can be concluded that she/he is interested in the appropriate exhibit or topic. The third parameter measures how often a visitor requests information from the Virtual Tour Guide and what kind of information she/he wants to know. A high number of requests indicate interest. All the gathered data, such as which rooms have been visited and which exhibits have been viewed are the tracked parameters that are saved in the profile and can be used immediately and thus affect the remainder of the tour or the next tour when the same visitor returns.

3.2.3 Nonlinear Storytelling

The Virtual Tour Guide imparts information to the visitor by using nonlinear storytelling techniques. Rather than following a predefined tour and listening to a story that is the same for all visitors, the visitor is allowed and encouraged to make choices that determine the development of the tour and story. This is made possible by segmenting the information in small and easily-understood information chunks. These information chunks can be combined according to the choices and preferences of the visitor that are stored in the profile and constantly updated by the visitor tracking. The result is a personalized tour. Nonlinear Storytelling techniques have been utilized in numerous systems. Examples can be found in [Braun 2002] and [Clanton et al. 1998].

The following two sections explain two integral parts of nonlinear storytelling. The first addresses the hierarchical

relationship between the information chunks and the second describes the learning system that enables the Virtual Tour Guide to select the relevant information chunks.

Nonlinear storytelling relies on a hierarchy of relationships between information chunks. The hierarchy defines in which way the information chunks can be combined. We chose a weighted, bidirectional graph of interconnected exhibits as the overall hierarchy for our Digital Heritage scenario. Each node of the graph contains all the prioritized information chunks about one exhibit. These information chunks can be text, that the Virtual Tour Guide narrates, or videos, images, and other media that can be shown to the visitor. The edges between nodes represent a relationship between exhibits. All edges outgoing from one node make up the various ways in which the story and tour can continue.

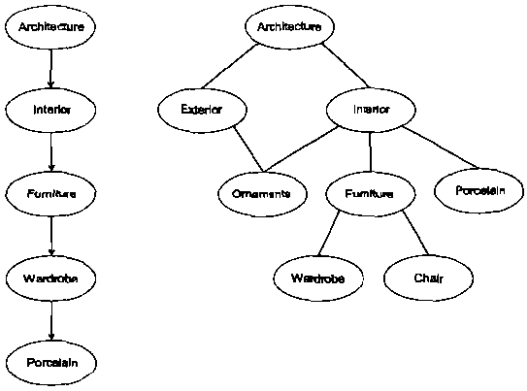

Figure 4: Information Hierarchy for Linear and Nonlinear Storytelling

The Virtual Tour Guide decides which of the information chunks of the current exhibit he presents. Depending on the interest of the visitor that can be one or more. He also chooses one of the outgoing edges to continue the story and tour with. The Virtual Tour Guide uses his learning system and the profile of the visitor to make these selections. In addition, the visitor can ask for specific information or exhibits directly.
Due to the chosen hierarchy it is possible that a visitor is presented with information about the same exhibit but at a different time and in a different context. We distinguish between the overall importance of exhibits and their importance in a particular context. An example is an exhibit like a silver plate. It can be shown and mentioned in the context of arts and crafts. If, at a later point in time, the story deals with the dining room, the Virtual Tour Guide may decide that it is important to show and give information about the same silver plate even though the visitor has seen it already. However, he will choose information chunks that were not presented to the visitor before.

The learning system of the Virtual Tour Guide uses the visitor profile and the information hierarchy to decide on how to proceed with the story and tour. The result of one learning step is a modification of the weights and priorities in the information hierarchy graph. The Virtual Tour Guide uses local and global learning. Local learning only uses data that the current visitor provides, whereas the global learning uses data collected from all visitors.

The local learning is a concept of an activation network. After the visitor tracking detects that the visitor is interested in an exhibit, the local learning increases the importance of this exhibit and also increases the importance of all exhibits that are near the selected one by increasing the weight of outgoing edges. The visitor's interest is detected when she/he either spends more time in front of an exhibit than the exhibit's holding time or request information on this exhibit. Learning by increasing the weights of exhibits is called positive learning. We also utilise negative learning whereby the weights and priorities are decreased. This happens when the visitor is obviously not interested in an exhibit. This is detected by the visitor tracking when the visitor passes by an exhibit or when she/he does not follow the Virtual Tour Guide's recommendation to take a look at an exhibit. The local learning can have an immediate effect on the visitor because the Virtual Tour Guide immediately uses the modified graph to decide on the next exhibit. The adjusted weights and priorities are stored in the visitor profile. They reflect the preferences of this visitor and have no immediate effect on other visitors. The next time this visitor uses the application, the values of the information hierarchy graph will be adjusted according to her/his profile. Other known visitors have their own version of the information hierarchy graph. New visitors start with the default one that is defined by the global learning.
The global learning analyses the profiles of all visitors. This is triggered whenever a visitor leaves or after a defined time period. Modifications of the global learning can have an effect on all visitors. One goal of the global learning is to verify and adjust the three parameters Object Holding Power, Attention, and Request that are tracked for each exhibit. The second goal is to adjust the weights and priorities of the default information hierarchy graph for new visitors. Since the Virtual Tour Guide does not know the interests and preferences of new visitors, he shows them the exhibits that were interesting to the majority of previous visitors by using the default graph and following the edges with the highest weights and presenting the information chunks with the highest priorities. The global learning is dependant on and improves with the number of visitors.
The Virtual Tour Guide also has a small set of behavioural states with transitions between them. These states are used to trigger different interventions of the Virtual Tour Guide. An intervention means that the Virtual Tour Guide appears in front of the visitor even if he was not called. This happens when he has to inform the visitor about important information. An example is when the visitor passes by an important exhibit that she/he has not seen. Another example for an intervention is offering assistance when the visitor seems to be lost or has problems navigating. The transition from one behavioural stage to the other is triggered and controlled by the visitor tracking.

4 Conclusions and Future Work

In this paper, we presented a framework for developing a Digital Heritage application. To achieve our goal of creating a dynamic Digital Heritage application that is both pedagogical and entertaining and one that is user-friendly to the general public, we incorporated intuitive interaction methods such as the Virtual Tour Guide and the Chinese Calligraphy brush and well as non-linear storytelling techniques that presents customized content based on visitor tracking and visitor profiles. The Virtual Tour Guide is able to 'learn' the user's behaviours and intentions and dynamically change the context of the visits personalized for each user. Integration of a Chinese calligraphy brush provides further freedom to the users.

Future work includes developing more natural facial expressions and animation sets for the Virtual Tour Guide, further exploitation of the possibilities of using the calligraphy brush as an interaction deviee, further implementation of the user tracking system for Virtual Tour Guide learning and personalized virtual tours, and to conduct user test studies to evaluate the proposed interaction methods.

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