# VISUALIZATION AND HAPTIC RENDERING OF ANCIENT WOODCARVINGS IN SRI LANKA

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**ABSTRACT**: Virtual reality and 3D computer graphics are increasingly been employed on reconstruction of cultural heritage sites and archaeological museums in Europe, less effort has been spent on evaluating the use of different Information and Communication Technologies (ICT) as well as 3D computer graphics for reconstructing heritage sites in South Asia. This research presents a case study focused on the visualization and haptic rendering of ancient woodcarvings in Sri Lanka. Embekke is a very special shrine because it owns collection of the greatest woodcarvings in Sri Lanka. According to archaic documents, it was built during the 14th Century. The historical records suggest that the King Wickremabahu III, who reigned in Gampola from 1359 to 1374, built this shrine and dedicated to God Kataragama. This paper proposes a virtual reality framework for visualizing ancient woodcarvings in Embekke, that offers a wide set of features to support realistic rendering, advanced human computer interaction and stereoscopic display technology. In order to achieve a realistic visual simulation of woodcarvings, we used several texture mapping techniques, while haptic device has been utilized to simulate the sense of touch.

**Keywords:** virtual woodcarvings, haptic rendering, parallax mapping, and visualization.

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## 1. INTRODUCTION

3D Computer graphics and advanced media technologies have long been used to preserve or virtually visualize cultural heritage sites [1, 2, 4, 5, 6, 8]. Virtual reality and haptic-driven cultural heritage experience shall ideally give to the user the opportunity to feel that they are present at significant places and times in the past, stimulating a variety of senses in order to allow the experiencing of what it would have felt like to be there. While a number of research works on preservation and virtual reconstruction of archeological sites in Europe and Egypt [11, 12, 13, 14], less effort has been spent on introducing new information and communication technologies to visualize and preserve cultural heritage sites in some other regions of the world like South Asia. This research presents a case study for realistic visualization and haptic rendering of ancient woodcarvings in Sri Lanka. Embekke is a world-famous shrine because its vast collection of the elegant woodcarvings [9, 15]. Archaic documents and epic Embekke-Varnanawa imply that the shrine was built around 1359-1374 A.D. during the reign of King Wickremabahu III, and dedicated to God Kataragama. Enticing woodcarvings of Embekke shrine were recognized by UNESCO as the greatest carvings on the wooden pillars to be found in any part of the world.

The goal of this work is to visualize and virtually reconstruct this cultural heritage site. This paper presents a virtual reality framework for realistic visual simulation of ancient woodcarving works with the use of advanced human computer interaction technologies. In order to achieve a realistic visual simulation of woodcarvings, we used several texture mapping techniques such as parallax occlusion mapping [3, 7, 10] with lighting models, while haptic device has been utilized to simulate the force feedback. The polygonal models of every relief are used in order to achieve a haptic simulation of the selected woodcarvings. AutoDesk Maya 2008 package was used for the reconstruction of the 3D virtual shrine using polygonal modeling techniques.

To enhance intuitive haptic interaction, we used the Reachin display that integrates a PHANTOM omni haptic device with stereoscopic vision. Furthermore, we improved interactivity by enabling not only single haptic device interaction with a Reachin display but also dual haptic interactions for camera navigation and virtual touch in the same environment with two PHANTOM omni haptic devices.

The remainder of the paper proceeds as follows. Section 2 illustrates historical information of the Embekke shrine and its woodcarvings. Section 3 shows overview of the framework. Section 4 presents the techniques associated with the visualization of the ancient carvings, which render realistically in real-time. Section 5 shows details of haptic rendering and interaction. Section 6 discusses the results of our visual and haptic simulations. Finally, future directions and conclusions are discussed in Section 6.

## 2. ANCIENT EMBEKKE SHRINE

The Embekke Shrine is situated at the village of Embekke (also written as, Embakka, Embakke, Ambakka, and Ambakke) in the area known as Udunuwara in the Kandy district of Sri Lanka. It lies close to Daulagala about 16 km from the World Heritage city of Kandy [9, 15]. More precisely it locates at a distance of 116 km from Colombo city, and at 488.6 meters above sea level (Figure 1).

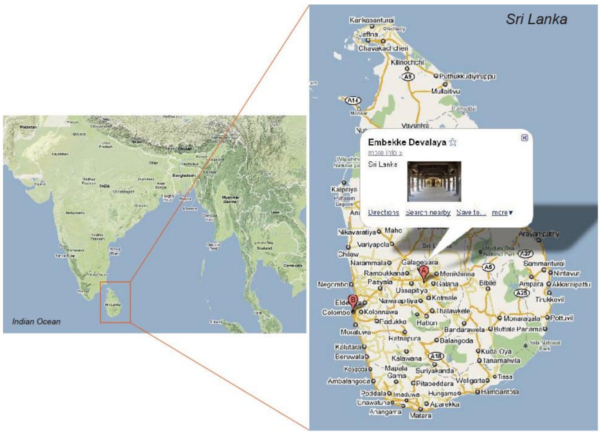


Figure 1: Location of Embekke shrine.

Embekke shrine is very famous the world over for its own collection of the ancient woodcarvings. The UNESCO has recognized these carvings on the wooden pillars to be the greatest carvings to be found in any archeological location of the world. Available historical records suggest that the King Wickremabahu III built this beautiful shrine during the period of his reign in Gampola from 1359 to 1374 A.D., in honor of the God of Kataragama [9].


Figure 2: Photograph of dancing hall (top), and inside of the hall (bottom).

This shrine consists of two segmented buildings, the Dancing Hall (*Digge*) and

Drummers Hall (*Hewasi Mandappaya*). The dancing hall is 52 feet 10 inches long and 25 feet 9 inches wide (Figure 2). It comprises 32 square-shaped pillars. There are 16 wooden pillars at the entrance of the shrine. These pillars were made using local timbers like *Gammalu. Ginisapu*, *Na* and *Pihibiya* timbers have been used in the other sections. Most of these intricately carved wooden pillars have stone pillars as their base.

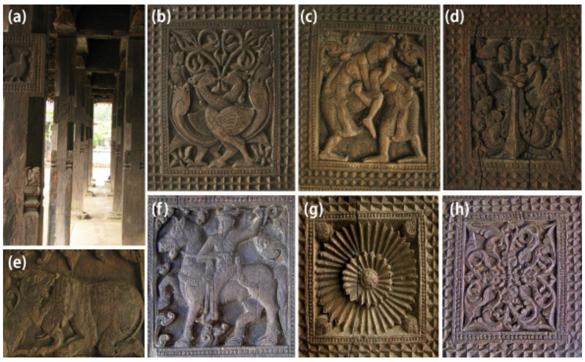

Figure 3: Photographs of pillars (a), and few attracted carvings on pillars.

Almost the entire structures of wooden buildings are decorated with elegant carvings in *Gampola* era. Some believe these carvings have been done by an artisan known as *Devendra* Mulachari [15]. The carvings include lions, swans, bulls, elephants, double-headed eagles, leaf patterns, wrestlers, soldiers, horse riders, dancing women, mermaids and lotus motifs (Figure 3).

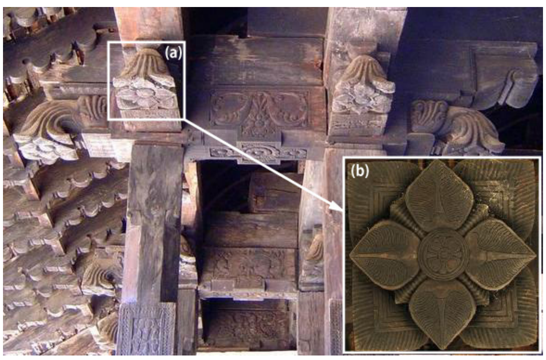

Figure 4: Woodcarvings on the Pekada (a) and roof members.

Each pillar is surmounted by four carved wooden-capitals (called *Pekada*). Each There are altogether 128 carvings in these pillars and all these carvings are different from each other. Pekada, when viewed from below has been carved to represent an inverted lotus (Figure 4). Among the carvings, there are 125 series of decorations, 256 flower bordering (*Liyawel*), 64 lotus designs in Pekada, and 30 decorative patterns on timber, roof members, making a total of 514 such graceful carvings.

## 3. FRAMEWORK OVERVIEW

The proposed framework offers an extensive set of features to support realistic rendering, advanced human computer interaction and display technology (Figure 5). The main technical challenge of the presented case study is to achieve a realistic representation of the appearance of Embakke shrine and its carvings in a 3D interactive real time environment, while maintaining a force-feed back for haptic rendering. Since the final framework is tailored for two different applications, namely a real-time realistic visualization and a haptic simulation, a balance between the requirements of these two outputs is required. In order to face the challenge of such a complex interaction, and to prepare it for a real-time simulation, different techniques are focused.

The framework was developed using C++ in Visual Studio 2005 development environment and is based on OpenGL API and the OpenGL 2.0 Shading Language (GLSL) for the graphics, on the "OpenHaptics" and "QuickHaptics" libraries for controlling the operations of PHANTOM haptic device.

## 4. VISUALIZATION

Since the amount of geometrical detail, and thus the total number of polygons that can be used to render the geometrical complexity of a give model, ought to consider the available hardware limitations of the computers and the inherent constraints of any real time application, a careful preparation and

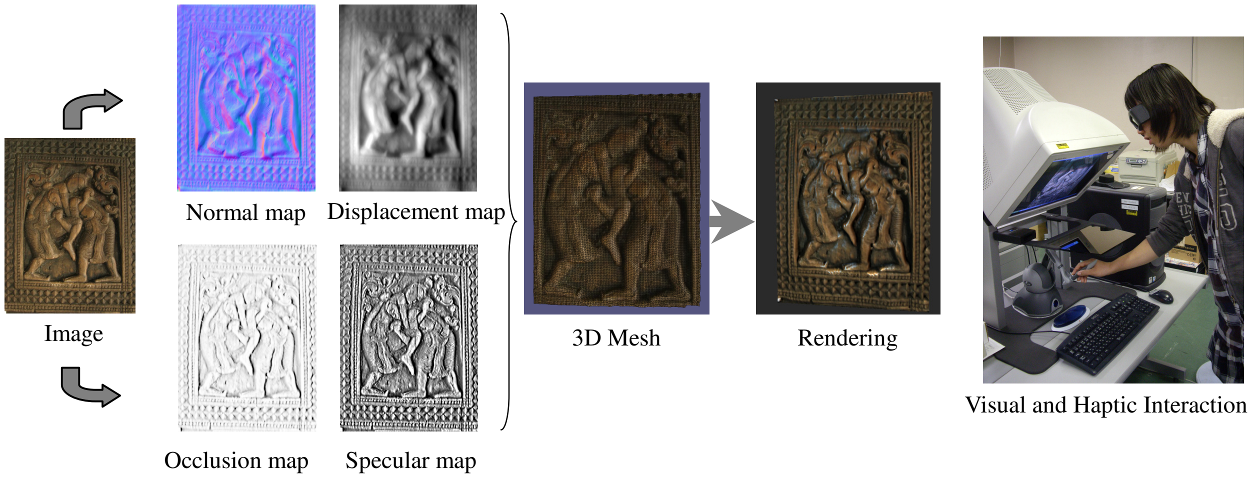


Figure 5: Framework for realistic visualization and haptic rendering of ancient woodcarvings.

optimization of the modeled 3D meshes is necessary in order to ensure real time visualization and interaction capabilities. In order to meet the needs of real time visualization, a simplified version of the 3D model of the shrine has been prepared and all the carved decorations of wooden pillars are rendered by using texture mapping techniques such as parallax occlusion mapping [3, 7, 10] with the previously prepared textures of the woodcarvings (Figure 5). This was on the one side a benefit to the framework, but on the other it introduced a new challenge of how to make haptic interaction of woodcarvings without geometric details in simplified 3D models. The extra modeling work is needed to generate relief surfaces of each woodcarving for haptic interaction.

### 4.1 Modeling

The first task was to reconstruct the buildings of ancient shrine. Three-dimensional polygonal models were created based on architectural plans, visual measurements and historical documents using the AutoDesk Maya 2008 modeling package (Figure 6). Wherever possible, the model's surfaces were defined as single sided objects in order not to burden the final meshes with an extravagant amount of hidden polygons. Critical works of modeling, such as woodcarvings, due to its extremely complex geometrical features, were given special attention to generate relief surfaces of woodcarving by using normal estimation methods. We based on previous works called "*shape-from-shading*" [16, 17], and computed surface normal from the shading information in the image as shown in Figure 7.

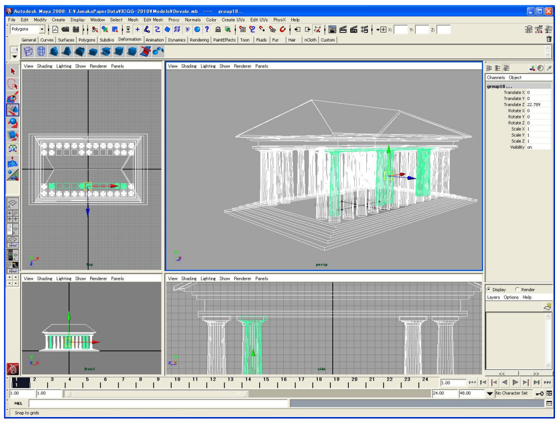

Figure 6: Screenshot of modeling 3D Shrine in AutoDesk Maya 2008 software package.

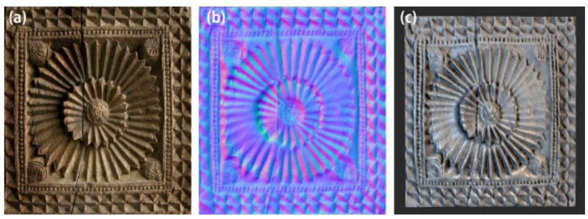


Figure 7: 3D reconstruction of a relief surface of a woodcarving, input image (a), normal map (b), and reconstructed 3D model (c).

Special care was given to keep an acceptable trade-off between visual accuracy and the performance of the real time haptic interaction.

### 4.2 Real-time Rendering

Global Illumination techniques and multi-pass technique were used in order to compute lighting solutions for real-time rendering. The parallax occlusion mapping technique provided the ability to render complex woodcarvings with very fine features in real time. In order to render the same objects interactively with equal level of detail, the meshes would need an extremely detailed triangle subdivision, which is impractical even with the currently available GPUs. Illumination techniques and parallax mapping technique were implemented in GPU programmable shaders to take advantage of resulting in highly interactive frame rates.

## 5. HAPTIC RENDERING

Haptic technologies provide tactile stimulation and force feedback. One of the main objectives in this multimodal framework is to provide haptic interface for rendering ancient woodcarvings. An advantage of this interface is possible to make haptic interaction with 2.5D relief surfaces of the complex woodcarvings and 3D model of the shrine. Through the use of our proposed framework, visitor/user feels the shape and geometric details of the ancient carvings and see the realistic visualization in the screen as shown in the Figures 5 and 8.

One of the major challenges in haptic rendering is performance. In typical computer graphics, we can use texture maps to add visual detail to a scene, while keeping the geometric complexity relatively low. It is not always an appropriate method for haptic rendering. High quality haptic shape rendering implies a rich geometric description that can be explored through the proxy position. The "*TriMesh class"* in the QuickHaptics API was used to load geometric models, it has a parser for OBJ, 3DS, STL and PLY formats.

### 5.1 Rendering for 3D display

To intensify intuitive haptic interaction, the framework has been enabled to render 3D stereoscopic output for the *Reachin Display*. As shown in Figure 5 (right most), the Reachin display integrates a PHANTOM Omni haptic device with stereo monitor and stereoscopic vision glasses. By using semi-transparent mirror, graphics and haptic can be co-located, and the user can see and feel the virtual object in the same place. Thus more intuitive visibility can be obtained.

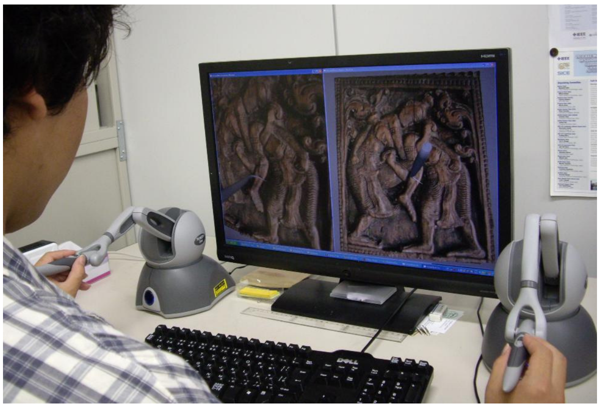

Figure 8: Dual-haptic interaction.

### 5.2 Dual Haptic Interaction

We have improved interactivity by enabling not only single-haptic device interaction with a virtual environment but also dual-haptic interaction in the same environment by using two PHANTOM haptic devices as shown in Figure 8. Left haptic device controls camera operations and right device controls the haptic cursor operation, while both devices providing tactile feedback. This proposed dual-haptic interaction allows users to adjust the degree of displayed details as well as viewpoints, while inspecting virtual woodcarvings.

## 6. RESULTS

The proposed framework was performed on a standard PC equipped with a 3.33 GHz Intel Xeon CPU and a NVIDIA Quadro FX 4600 graphics board with a 768MB video memory. Figure 9 shows results of realistic reconstruction of two lotus carvings on the Pekada, left column for input images, and right column for rendered results.

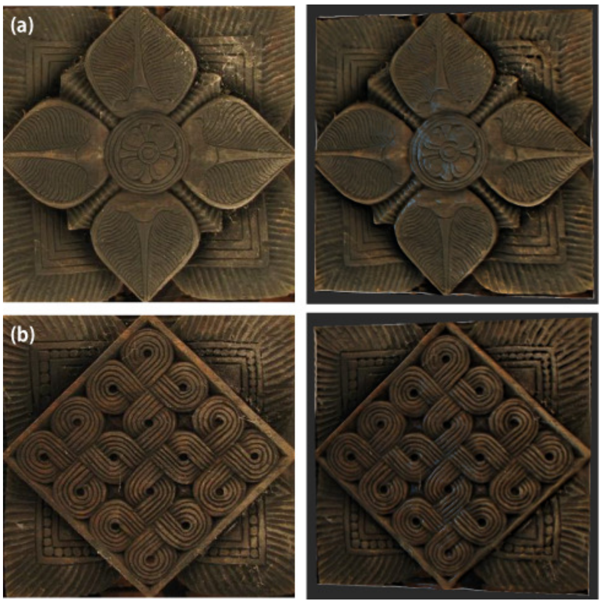


Figure 9: Realistic reconstruction of two carvings on the Pekada, left column: input images, right column: rendered results.


Figure 10: Realistic reconstruction of two complex carvings, left column: input imagess.


Figure 11: Realistic reconstruction of some attracted carvings, left column: input images, right column: rendered results.

Figure 10 depicts reconstructed two complex carvings, while left column showing input images, and right column for rendered results. Figure 11 presents the results for reconstruction of famous attracted carvings, namely *Hansa-Puttuwa*(entwined swans)(a), *wrestlers*(b), and *Lion vs. Elephant*(c), left column shows input images. Figure 12 shows reconstructed relief surface of the famous wrestlers carving (left), consisting 14356 vertices and 28231 faces. It has been reconstructed by using Shape-from-Shading (SfS) algorithm. Note in zoon-in-view of the surface (Figure 12, right), it suffers from some distortions and non-homogeneity. The traditional SfS algorithms are not suitable for reconstructing relief surfaces of complex woodcarvings.

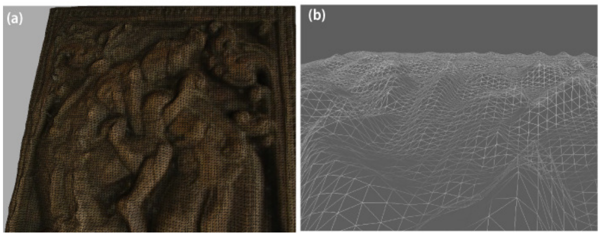

Figure 12: Reconstructed relief surface of the famous wrestlers carving (left), and one zoon-in-view of its polygonal surface (right).

## 7. CONCLUSIONS

This paper has presented ongoing research project to develop a framework for realistic visualization and haptic rendering of ancient woodcarvings in Sri Lanka. The development of this framework as well as its interaction techniques has taken an innovative approach to introduce ICT technologies to visualize South Asian cultural heritage site. The results show how the multimodality displayed by the system was received with diverse responses, reconstructing a more accurate surface details: that of realism against interactivity.

We will plan to use technologies, which allow to acquisition of more realistic surface, like laser scans or advanced simulation models. This would enable a smoother reconstruction of complex carvings as well as buildings. Future work should also include studies on how the multimodal interaction can work more closely together.


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