Image-based Capture, Modeling and Rendering for Cultural Heritage

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1 Introduction

Virtual Heritage (VH) is concerned with the digital representation and presentation of cultural artifacts along with the stories and facts that accompany them. In this work, we present an inexpensive, easy to use, Image-Based Modeling and Rendering (IBMR) system for capturing geometric and appearance models of heritage objects. Furthermore, we present several interaction paradigms for our image-based models, as well as a case study of our methods using a set of Inuit sculptures.

Specific applications of virtual heritage have spanned from digitally restoring and preserving objects [3], to the creation of virtual machines [5], or even the reconstruction of an entire ancient suburb [4]. Systems vary in terms of how the digital models are acquired, ranging from hand created 3D models to uncalibrated computer vision [7], or laser scanning techniques. Meanwhile, the majority of current VH content is presented using conventional images and text, or at best given a pseudo-3D look using 2D panoramas in Quicktime. The advantage of our IBMR approach is that the use of a single camera allows us to keep our system inexpensive, as opposed to requiring expensive laser scanners, while being as easy to use as taking some photographs. Moreover, the 3D models allow us to experiment with new ways of presenting content, ranging from descriptive movies, where the inanimate objects can be animated, to interactive games.

2 Capture

Our image based capture system uses Shape-From-Silhouette (SFS) to model the geometry, and a dynamic texture [2] to model the appearance variation observed on the estimated geometric model. The capture setup consists of a single camera, a solid colored background, and the object of interest on a rotating turntable (see Fig. 1). The capture process involves 5 steps:

- *capture/calibration* n Input images, $I_1, ..., I_n$. are acquired and the camera matrices $\mathbf{P}_i = \mathbf{K}[\mathbf{R}_i|\mathbf{t}_i]$, are automatically extracted from a planar calibration pattern similar to Canon's 3D S.O.M [1].
- *segmentation* The user selects background samples and a PCA analysis of the samples is used to classify a pixel as either foreground or background, giving binary images $S_1, ..S_n$
- *geometry acquisition* The user interactively chooses a bounding box of the object. The binary images S_i and calibration $\mathbf{P}_i$, are used as input to a SFS algorithm. We choose the method of Tarini et al. [8], and obtain as output a triangular mesh, with vertices $\mathbf{V} = \{v|v \in \Re^3\}$, and triangles $\triangle$.
- *texture coordinate generation* Following Levy et al. [6], the object is partitioned into pieces, and each piece is then mapped to 2D and placed into a rectangle, ensuring no overlap.
- *dynamic texture* The input images, I_i, are warped to the texture coordinates, giving n textures, T_i. A dynamic texture basis is derived from the texture images (see [2]). The texture basis compactly encodes the view-dependent light, and is capable of compen-

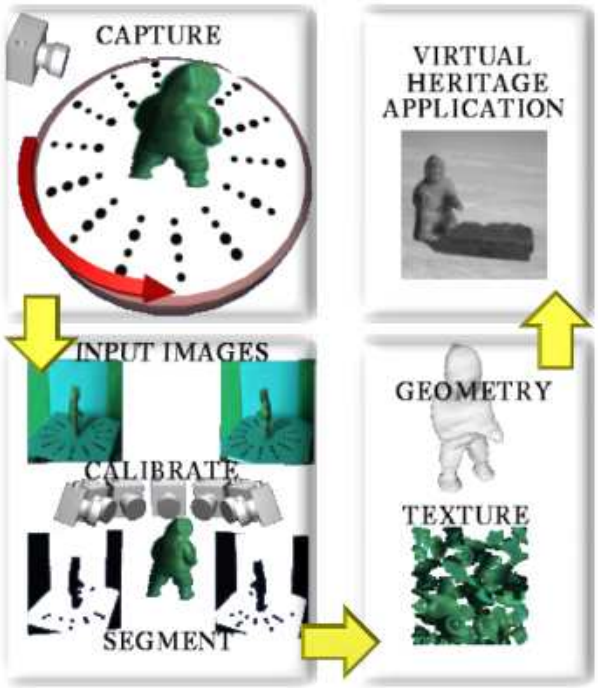

Figure 1: An overview of the capture process

sating for inaccuracies in the SFS geometry. During rendering, the texture for a viewpoint is obtained by blending the texture basis with an appropriate set of coefficients.

Typical user involvement in the capture process is minimal, but if necessary, the user is free to add/remove images from any stage, adjust parameters for the individual steps, or manually adjust the texture coordinates.

3 Content Presentation

Figure 2: Images of two of the seal hunt sculptures

We have studied several content presentation paradigms. The practical example here is based on the captures of a set of Inuit carvings depicting a seal hunt. Two of the total carving groups are shown in Fig 2. All of our content can be viewed online at http://www.cs.ualberta.ca/˜vis/models/sealhunt.

Figure 3: Novel renderings of individual sculptures

2D Images & Text & 3D Models In addition to simply presenting 2D images of the cultural content along with descriptive text, the IBMR models offer extra degrees of freedom. In this paradigm, the images are linked to the IBMR models, which appear in our object viewer (available at http://www.cs.ualberta.ca/˜vis/ibmr) and can be rotated, translated and zoomed in on (Fig.3). It is unlikely that a visitor to a museum would have such freedom to freely inspect the delicate sculptures.

Static World with Hypertext-Markup Navigation This paradigm is similar to what is currently available with Quicktime and Flash, where a static world is presented, and objects in the static world are linked to more specific information. For example, with the seal hunt sculptures, we can augment the image based models with an appropriate scene, namely a snowy backdrop and an Igloo

Figure 4: A couple frames of a movie made from the virtual models, rendered with Maya plugin

(similar to the dioramas typically displayed in museums). The user is then free to examine the objects in their natural environment and obtain more information as desired.

Animation / Movie We have also developed a plugin for Alias Maya to render our models. With the 3D geometric information and the plugin, we can animate the captured models, something that is impossible with the actual sculptures. Within this paradigm, we have created a movie of the seal hunt, where the scene is composed of synthetic backdrops, and the actors are simply animations of the lifeless sculptures.

Fully Interactive Environment Another paradigm, which is the topic of our future work, is the use of the our models in fully interactive 3D environments. This could be where the user either explores a 3D world containing the cultural objects, or the artifacts are animated as characters in a game. Using our case study, one such game would be where the user gets points for successfully hunting seals, and getting the seals home to the family, to use for food and clothing.

4 Conclusion

We have presented an inexpensive, easy to use Image Based Modeling system for use in virtual heritage applications. We have also described several interaction paradigms, and used a seal hunt example to show that within these paradigms exciting new content can be created and animated.

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