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El-Hakim, Sabry; Lapointe, Jean-François; Whiting, E.

Publisher's version / Version de l'éditeur:

ACM SIGGRAPH, 2008

National Research Council Canada
Conseil national de recherches Canada

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August 2008

* Proceedings of the International Conference on Computer Graphics and Interactive Techniques, SIGGRAPH 2008, Los Angeles, California, August 11–15, 2008.

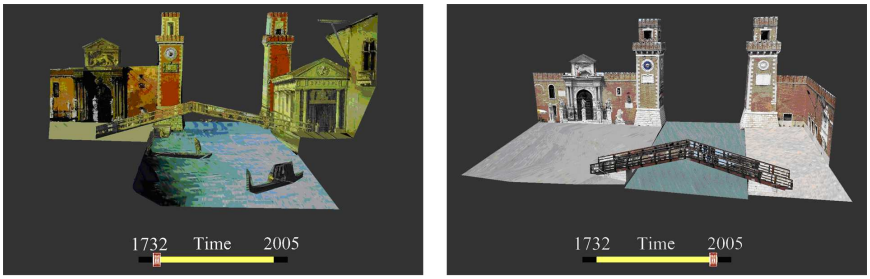
Canada

Digital Reconstruction and 4D Presentation through Time

Sabry F. El-Hakim*
Visual Information Technology
National Research Council Canada

Jean-François Lapointe†
Visual Information Technology
National Research Council Canada

Emily Whiting‡
Department of Architecture
MIT



3D Reconstruction from 1732 Canaletto painting

3D Reconstruction from 2005 images

Figure 1: *The 4D interactive presentation, with time slider, in the Demotride viewer.*

1 Introduction

Virtual time travel transforming the existing remains of a heritage site to its original condition has value for education and cultural understanding. However, digitally reconstructing objects which no longer exist is a challenge. Interaction and navigation within virtual 4D worlds (adding time to 3D worlds) is also problematic due to imprecise understanding of the time dimension. In this project we developed an approach to 3D modeling of sites that have undergone changes over the years. The method creates independent models from different types of data, such as frescoes, paintings, drawings, old photos, historic documents, and digitized remains. The models are assembled and integrated for a 4D interactive presentation. Several research issues have been addressed: (1) Modeling from frescoes and drawings with incorrect perspective, (2) modeling from paintings and old photos including fine geometric details from shading (3) coloring models from old photos and drawings to match existing elements, (4) creation of models by seamless and accurate integration of data obtained from independent sources, and (5) the creation of intuitive interactive presentations that link the models with other multimedia components and information related to the history of the site. We will describe contributions to these issues, including our own advanced model viewer [Dem], and apply them to modeling heritage sites such as Venice which appeared in paintings by Canaletto, Bernardo Bellotto, and Francesco Guardi, and many 19th century photos. Canalettos paintings have been used to measure the subsidence of Venice [Camuffo and Sturaro 2003].

2 Approach

Techniques to create models from frescoes, paintings, and old photos have been developed. For old frescoes or paintings with incorrect perspective, the method requires that part of the object or site still exists, for example, its foundation or archaeological remains. We use measurements from those remains to resample the source material, create an image with correct perspective, and use this to reconstruct the site. For Renaissance paintings, which have correct perspective, and old photos, we use our flexible approach for 3D construction from single images [El-Hakim 2001].

*e-mail:Sabry.El-Hakim@nrc-cnrc.gc.ca
†e-mail:Jean-Francois.Lapointe@nrc-cnrc.gc.ca
‡e-mail:ewhiting@csail.mit.edu

SIGGRAPH 2008, Los Angeles, California, August 11–15, 2008.
ISBN 978-1-60558-466-9/08/0008

The approach applies several constraints: coordinate constraints, surface constraints, and topological constraints in two steps: a calibration step and a reconstruction step. The solution is based on Photogrammetric principles.

It is challenging to develop effective tools for visualizing virtual sites in 4 dimensions, for use by experts and non-experts. There is no standard approach for interacting with the time dimension, especially with models of sites that have changed over time. Many approaches have been tried, however the outcome is usually only a pre-rendered movie, which bypasses the interactivity problems. We developed the Demotride viewer, which works with content based on VRML and X3D. Specifically, Demotride's support of time sensors allows animation of time and interaction with the 4D models. One feature that distinguishes Demotride from other viewers is its ability to provide what we call controlled interaction, where the user is bound to respect the visualization and interaction parameters specified by the content developer. For example, Demotride supports unique features that permit control of the walkthrough parameters (orientation speed and interaction technique) when navigating in the virtual scene.

The approach has been applied to Venice sites, such as Piazza San Marco and the Arsenale (figure 1), and other cities in Italy (Florence, Padua, Trento) and Canada. Since we are still refining the procedure, future work includes comprehensive evaluation of the interactive presentation alternatives, at various configurations, by several groups of users. Both experienced and non-experienced users will be drawn upon. Further work involves designing and implementing an immersive system.

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