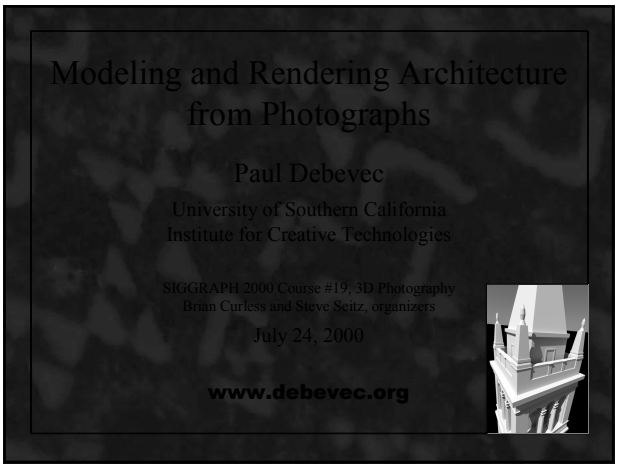
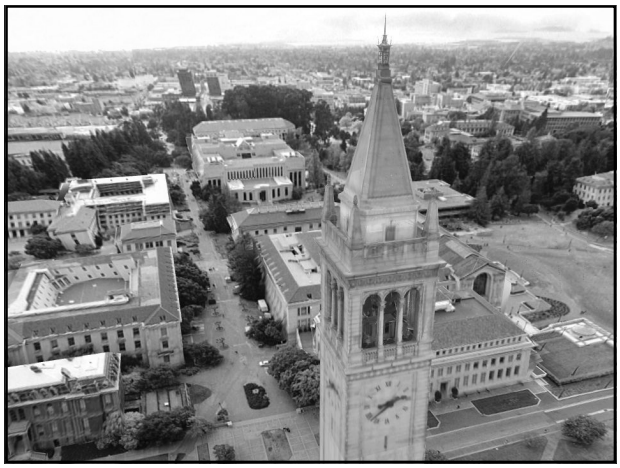
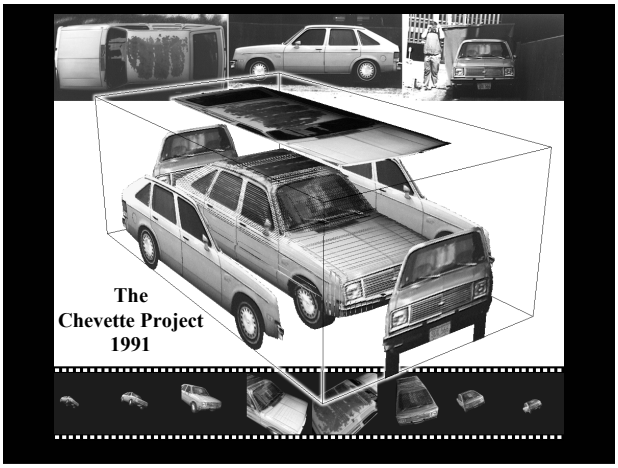
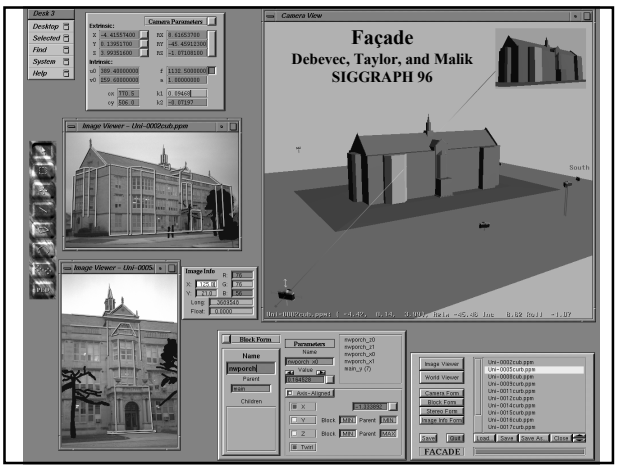

Modeling and Rendering Architecture from Photographs
Paul Debevec
University of Southern California
Institute for Creative Technologies
SIGGRAPH 2000 Course #19, 3D Photography
Brian Curless and Steve Seitz, organizers
July 24, 2000
www.debevec.org



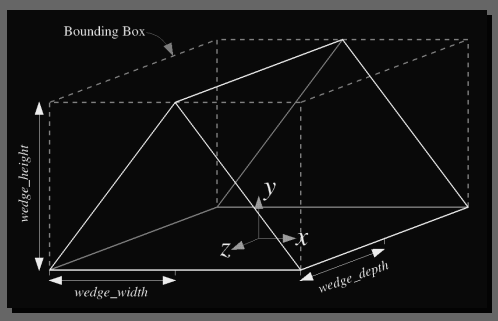

The
Chevette Project
1991


Stereo Image Capture Rig
Stereo Image Pair
Depth Map
Synthetic Views
Immersion '94
Michael Naimark
John Woodfill
Paul Debevec
Leo Villareal
Ramin Zabih
Interval Research Corporation
Ramin Zabih and John Woodfill. Non-parametric local transforms for determining visual correspondence. ECCV, May 1994.

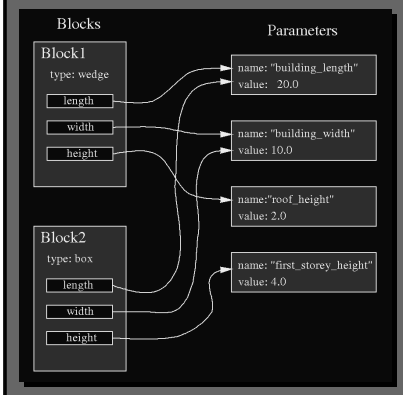

Modeling and Rendering Architecure from Photographs
(Debevec, Taylor, and Malik 1996)
Block Model
User-Marked Edges
Recovered Model
2000

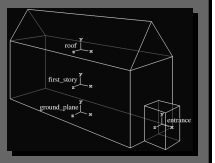

Façade
Debevec, Taylor, and Malik
SIGGRAPH 96
FACADE

Façade Blocks



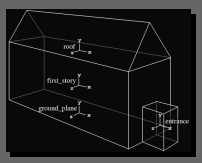
Parameterized Block





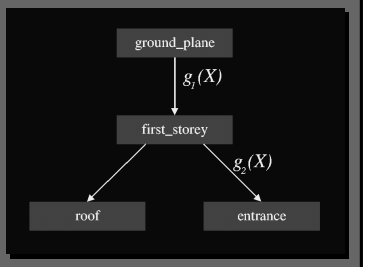
Parameter References

Model Hierarchy



Relation can be:

* Arbitrary 6 DOF
* Fixed Rotation
* Fixed Translation
* Geometric Relationship

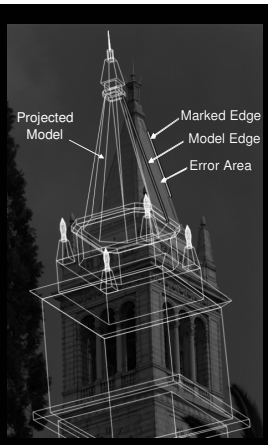


Reconstruction Algorithm

An objective function O measures the misalignment between the marked edges and the corresponding projected edges of the model

O is minimized with respect to the model parameters and camera positions

An initial estimate is obtained by a separate procedure



Algorithm with Initial Estimate Procedure

1. Solve for camera rotations, independently, based on edge orientations
2. Hold camea rotations fixed; solve for other parameters (often linear)
3. Perform full non-linear optimization, starting from near the solution

Video

Photogrammetric Modeling Summary

Modeling with blocks works because:

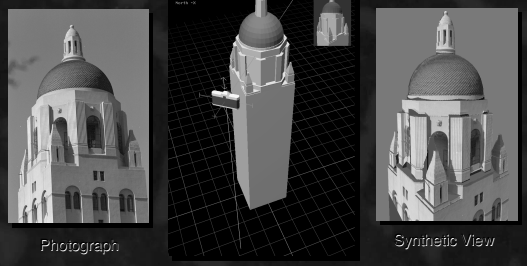
Convenient for architecture

Recovers Complete Models

Reduces number of model parameters, e.g.
Campanile model has:
2,896 parameters as independent edges
240 parameters as independent blocks
33 parameters as constrained blocks

- → Few marked features required
- → Easier to solve

Surfaces of Revolution

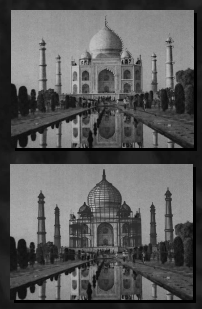


Photograph

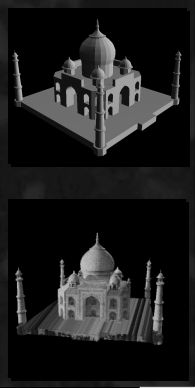
Recovered Model

Synthetic View

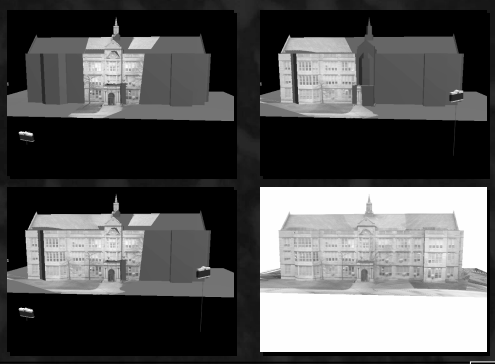
Arches and Surfaces of Revolution



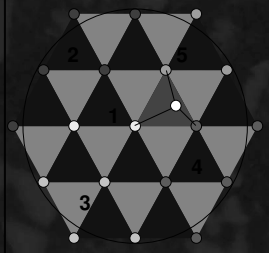
Taj Mahal modeled from one photograph



Rendering with Projective Texture Mapping



Rendering with View-Dependent Texture Mapping



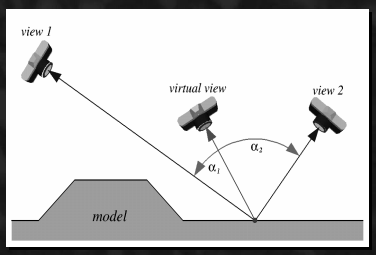
To render, determine to which triangle the viewpoint belongs

Compute Barycentric weights for the triangle vertices

Render the polygon with a weighted average of the three vertex images

Debevec, Borshukov, and Yu. Eurographics Rendering Workshop 1998.

View-Dependent Texture Mapping



View-Dependent Weighting Function

Image-Based Modeling, Rendering, and Lighting

SIGGRAPH 2000 Course #35

Tuesday, July 25, 2000

Room 243-245, Ernest N. Morial Convention Center

8:30am - 5:00pm

Paul Debevec
UC Berkeley

Michael Cohen
Microsoft Research

Leonard McMillan
MIT

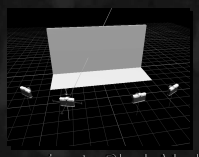
Chris Bregler
Stanford University

Richard Szeliski
Microsoft Research

François Sillion
iMAGIS - GRAVIR/IMAG

Scene with Geometric Detail

Model-Based Stereo



Approximate Block Model

Model-Based Stereo

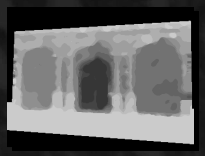
Given a key and an offset image,

- Project the offset image onto the model
- View the model through the key camera → Warped offset image

Stereo becomes feasible between key and warped offset images because:

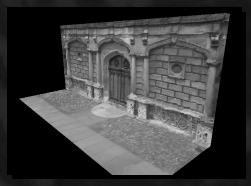
- Disparities are small
- Foreshortening is greatly reduced

Key Image | Warped Offset Image | Offset Image



Disparity Map

Synthetic Views of Refined Model



Four images composited with Model-Based Stereo and VDTM

Application: Rouen Revisited

(Golan Levin and Paul Debevec)

www.debevec.org/Rouen

Synthetic View: 1996 | Synthetic View: 1896 | Synthetic View: Monet Painting

(Uncalibrated Views)

Video

Application: The Campanile Movie

Paul Debevec, George Borshukov, Yizhou Yu, Jason Luros, Vivian Jiang, Chris Wright, Sami Khoury, Charles Benton, Tim Hawkins, Charles Ying

Thanks to Jitendra Malik, Jeff Davis, Susan Marquez, Al Vera, Peter Bosselman, Camillo Taylor, Eric Paulos, Michael Naimark, Dorrice Pyle, Russell Bayba, Lindsay Krisel, Oliver Crow, and Peter Pletcher, as well as Charlie and Thomas Benton, Linda Branagan, John Canny, Magdalene Crowley, Brett Evans, Eva Marie Finney, Lisa Sardegna, Ellen Perry, and Camillo J. Taylor.

Additional thanks: the Berkeley Computer Vision Group, the Berkeley Multimedia Research Center, the Berkeley Computer Graphics Group, the ONR MURI Program, Interval Research Corporation, and Silicon Graphics, Inc.

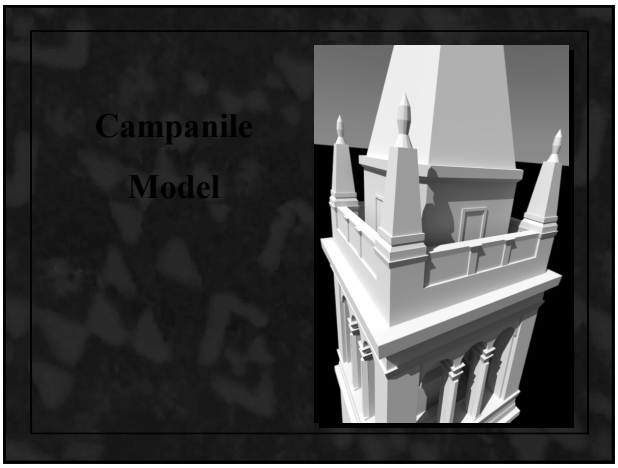
Cris Benton: Kite Aerial Photography

http://www-archfp.ced.berkeley.edu/kap/

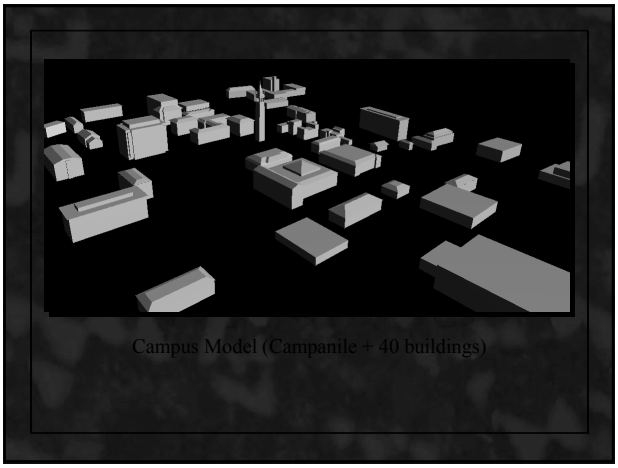
Cris Benton: Kite Aerial Photography

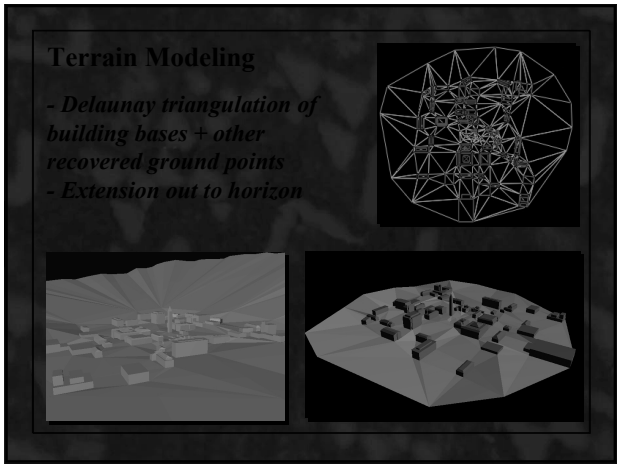
http://www-archfp.ced.berkeley.edu/kap/

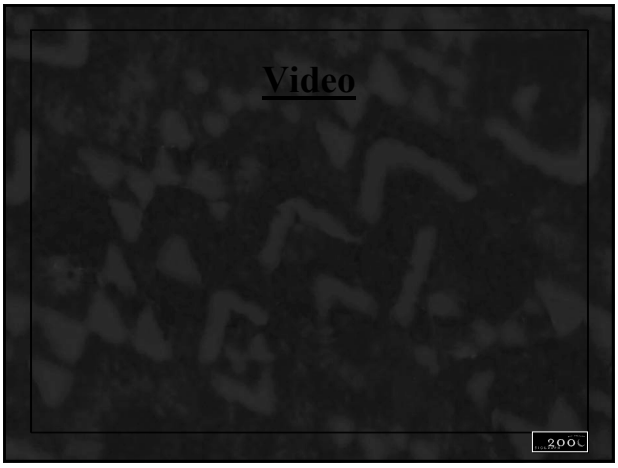
Tower Photographs

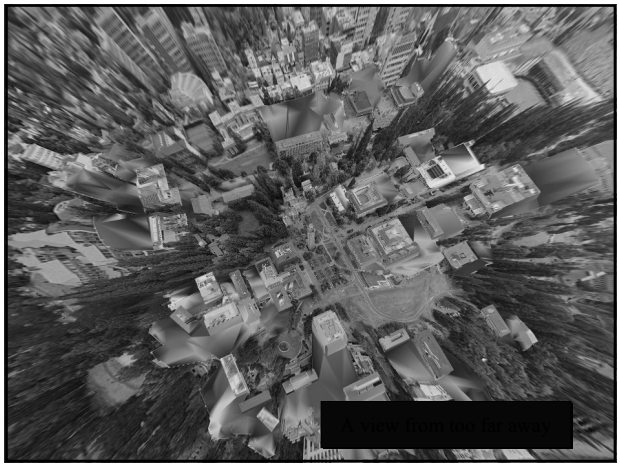

Campanile
Model


Environment Photographs


Campus Model (Campanile + 40 buildings)

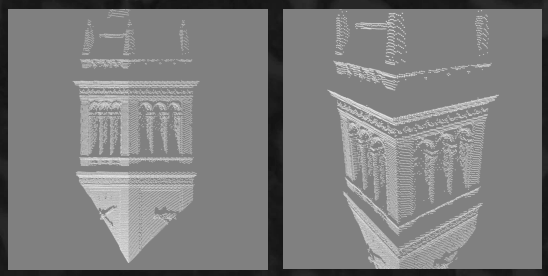

Terrain Modeling
- Delaunay triangulation of building bases + other recovered ground points
- Extension out to horizon


Video


A view from too far away

Comparison: Time-of-flight Laser Scanning

Laser scan of Berkeley's Campanile, courtesy of Cyra corporation



Application: The Matrix

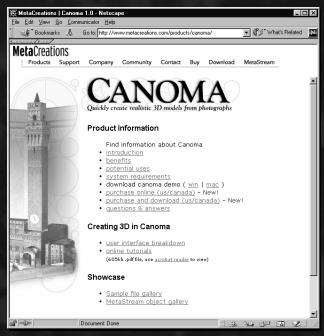
www.mvfx.com

George Borshukov, Dan Piponi, Kim Libreri, and John Gaeta, MANEX Entertainment

The Matrix – Reconstruction Stills – EF9

Video

Commercial Product: Metacreations (now Adobe) Canoma



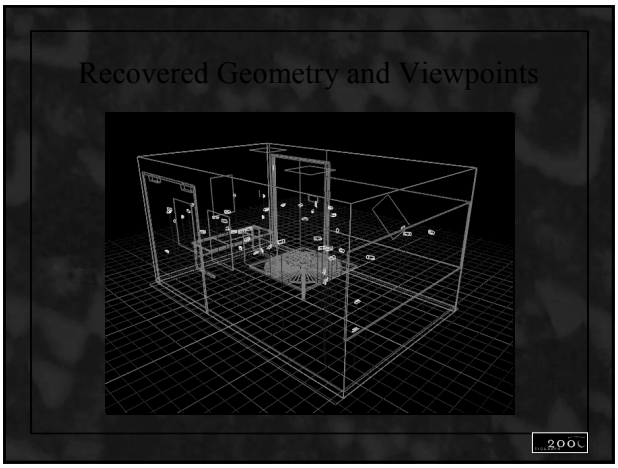
www.metacreations.com/canoma
www.canoma.com

Application: Inverse Global Illumination

Yizhou Yu, Paul Debevec, Jitendra Malik, Tim Hawkins

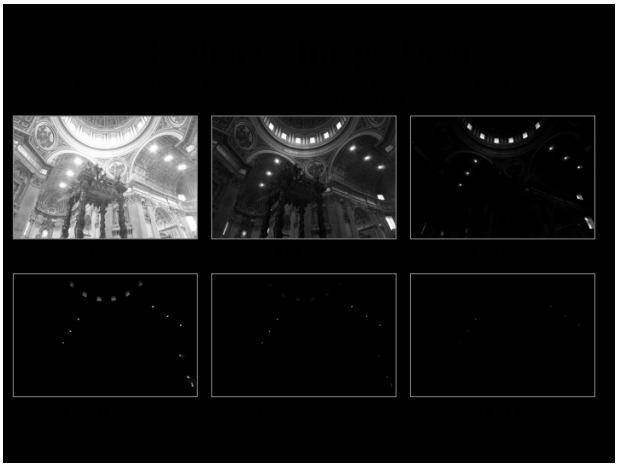
SIGGRAPH 99

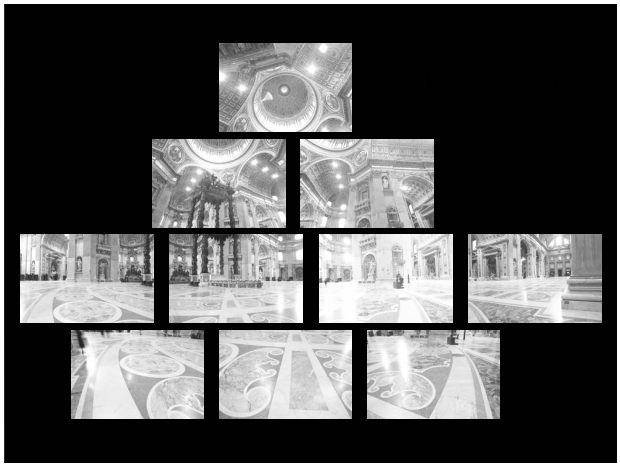
40 radiance maps of a room

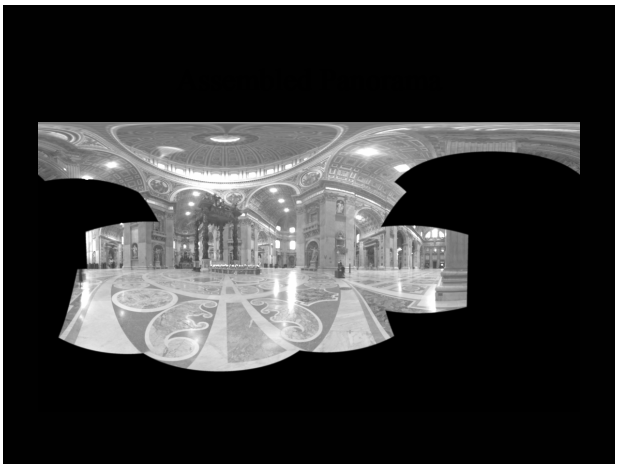

Recovered Geometry and Viewpoints

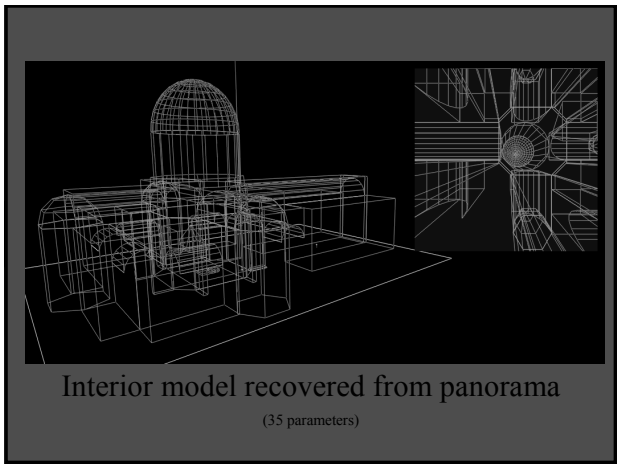

Real/Synthetic Comparison
Same viewpoints, Same lighting, Same objects

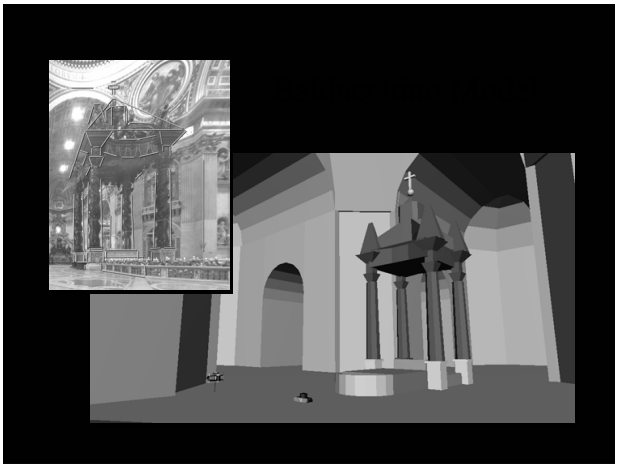

Real/Synthetic Comparison
New viewpoint, New lighting, New object

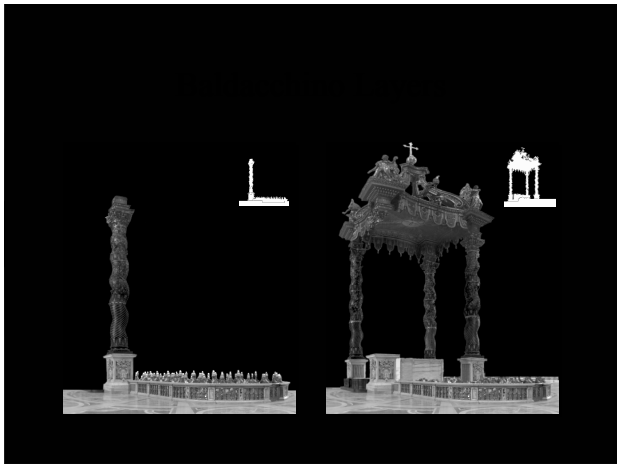


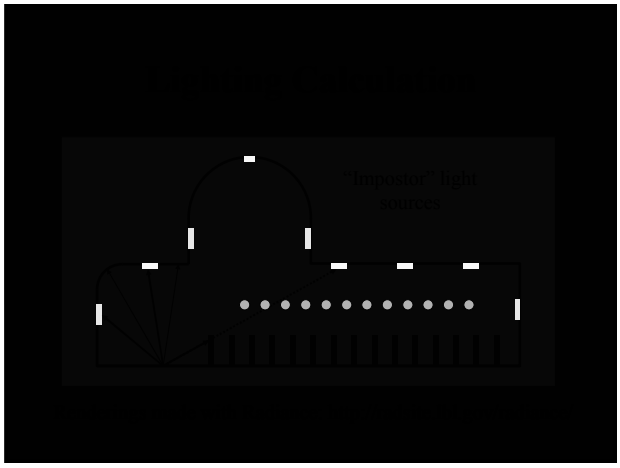





Interior model recovered from panorama
(35 parameters)






"Impostor" light sources

Thanks

Christine Cheng, H-P Duiker, Tal Garfinkel, Tim Hawkins, Jenny Huang, Sami Khoury, George Borshukov, Jason Luros, Jitendra Malik, Westley Sarokin, Camillo Taylor, Chris Wright