

Modeling and Rendering Architecture from Photographs

Paul Debevec

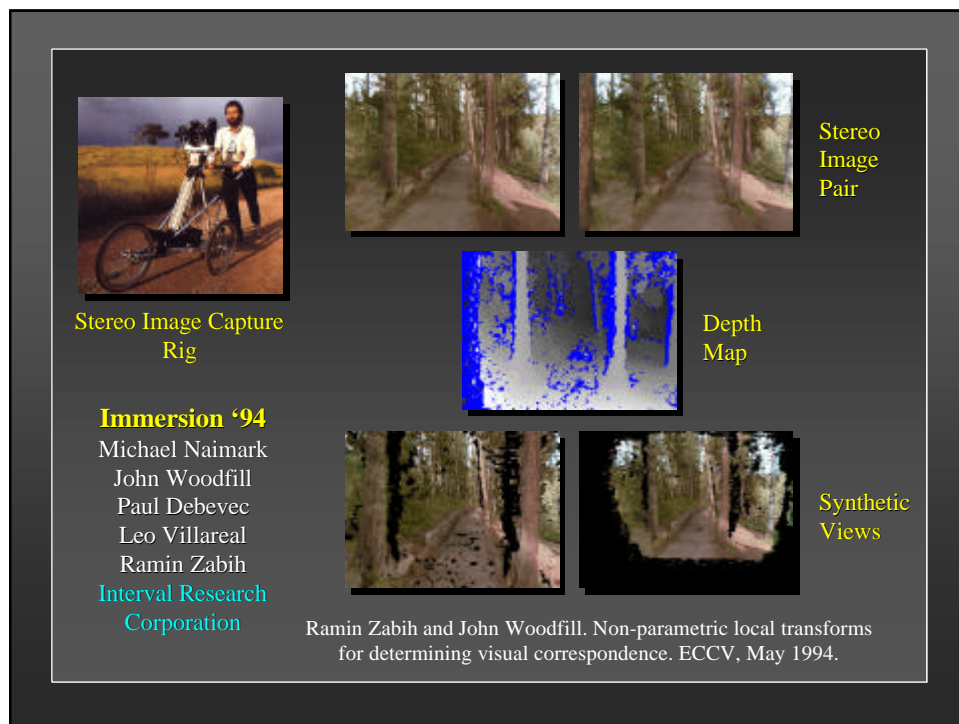
Computer Science Division
University of California at Berkeley

SIGGRAPH 99 Course #28, 3D Photography
Brian Curless and Steve Seitz, organizers

August 9, 1999

<http://www.cs.berkeley.edu/~debevec>





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.

Structure from Motion

Tomasi and Kanade 1992

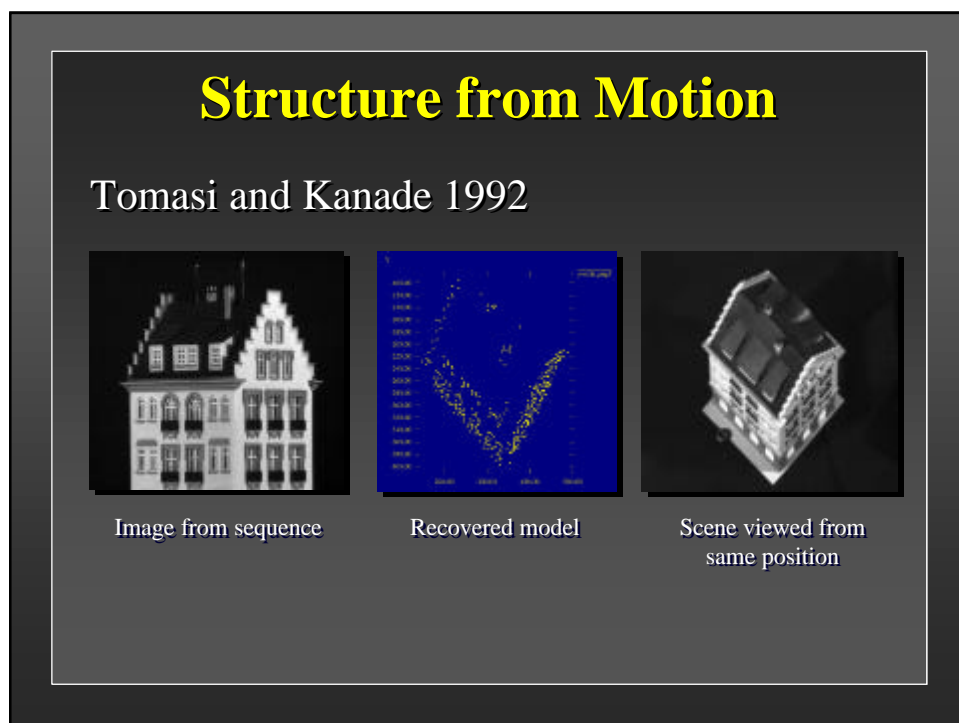


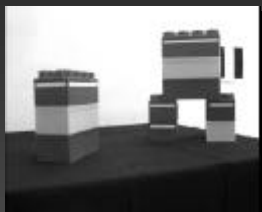
Image from sequence

Recovered model

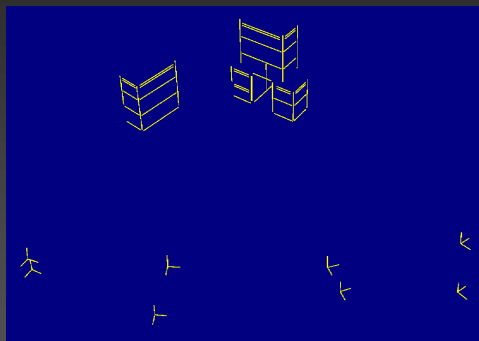
Scene viewed from same position

Structure from Motion

Taylor and Kriegman 1995



Two of eight original images

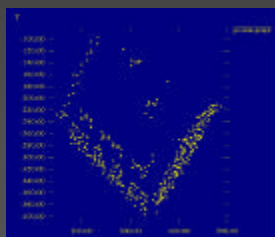


Recovered model

Tomasi and Kanade 1992

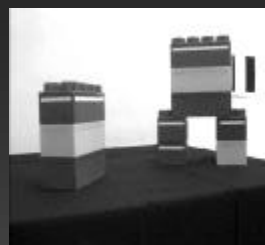


Image from sequence

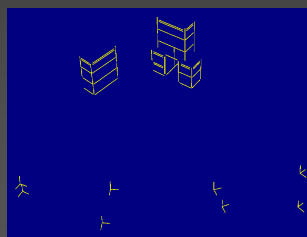


Recovered model

Taylor and Kriegman 1995



One of eight images



Recovered model

Façade's Modeling Method:

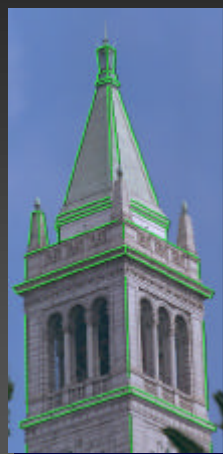
The **user** represents the scene as a collection of geometric primitives

The **computer** solves for the sizes and positions of the blocks according to user-supplied edge correspondences

Modeling and Rendering Architecture from Photographs (Debevec, Taylor, and Malik 1996)



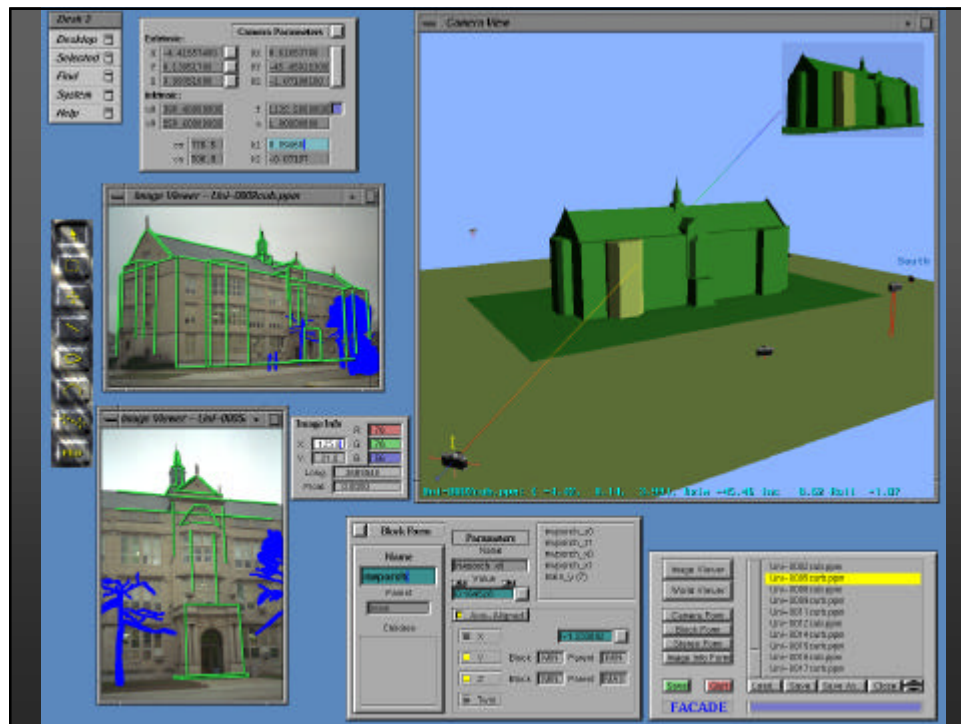
Block Model



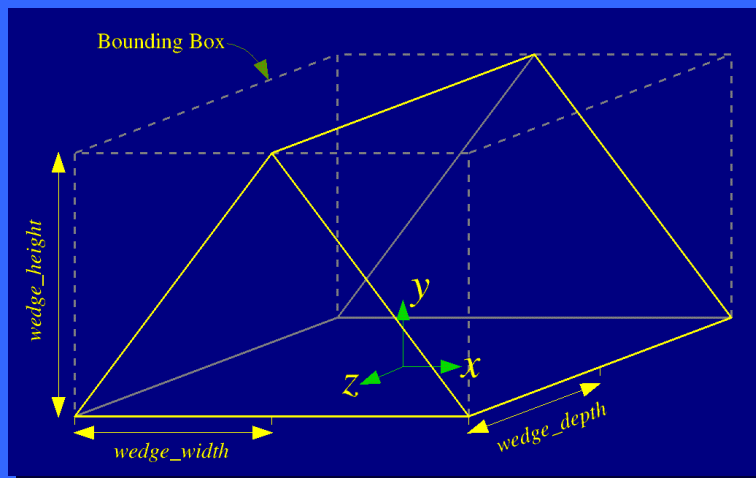
User-Marked Edges



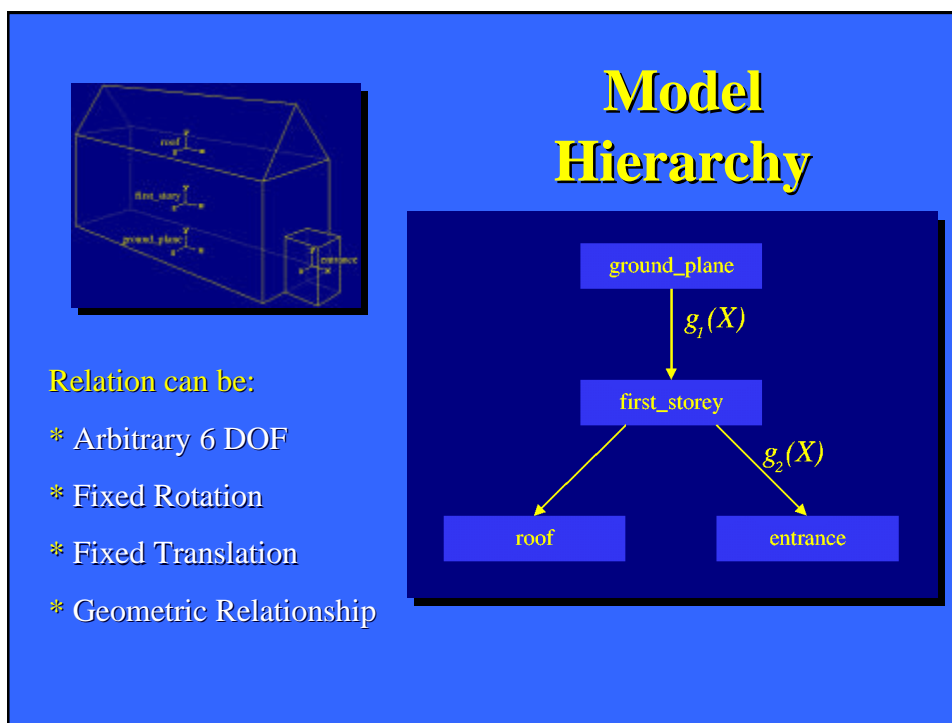
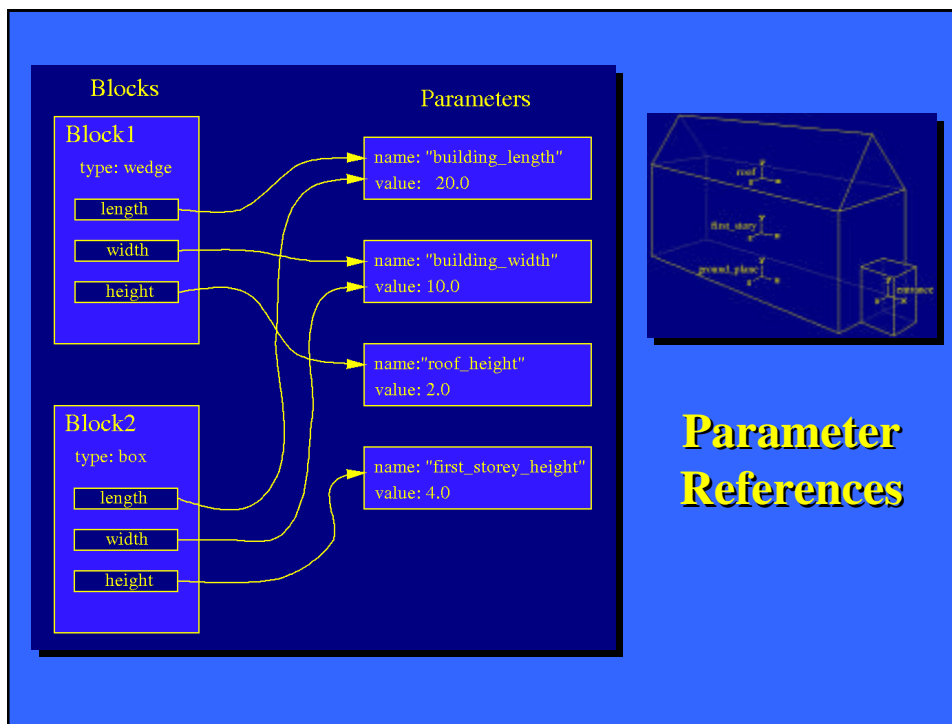
Recovered Model



Façade Blocks



Parameterized Block

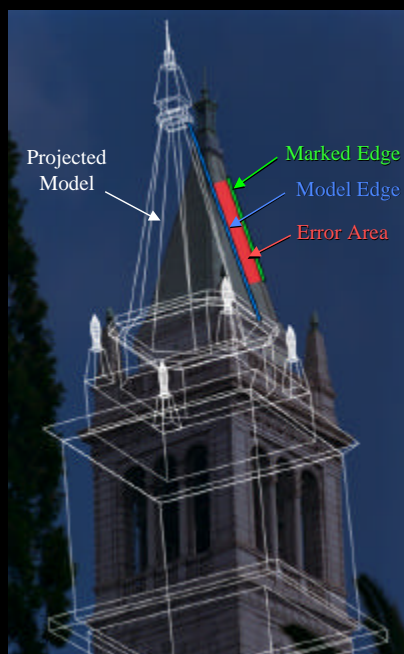


Reconstruction Algorithm

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 camera 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

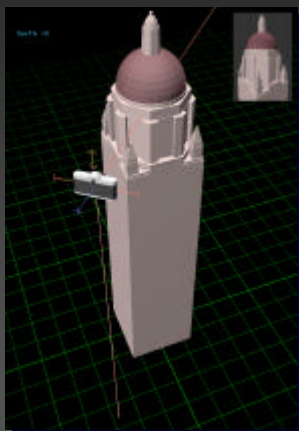
33 parameters as constrained blocks

- → Few marked features required
- → Easier to solve

Surfaces of Revolution



Photograph

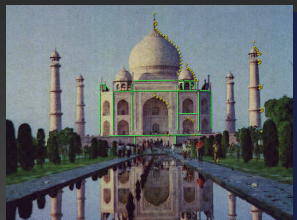


Recovered Model



Synthetic View

Arches and Surfaces of Revolution



Taj Mahal
modeled from
one photograph

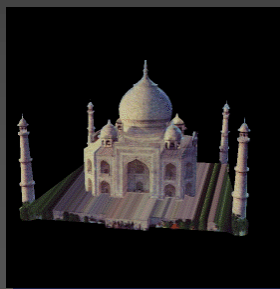
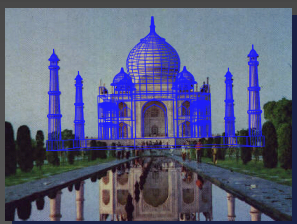
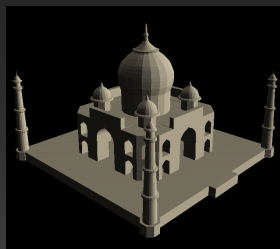


Image-Based Modeling, Rendering, and Lighting



SIGGRAPH 99 Course #39

Tuesday, August 10, 1999

Room 152, Los Angeles Convention Center

8:30am - 5:00pm



Paul Debevec

UC Berkeley

Leonard McMillan

MIT

Richard Szeliski

Microsoft Research

Michael Cohen

Microsoft Research

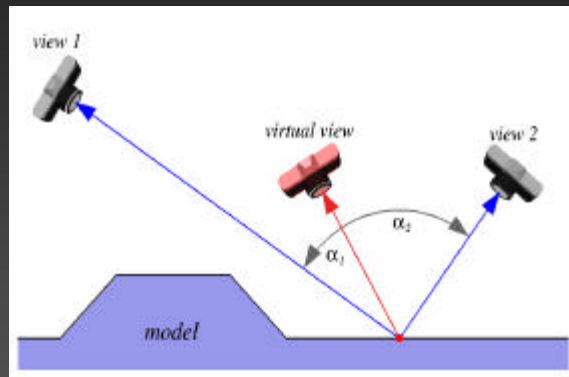
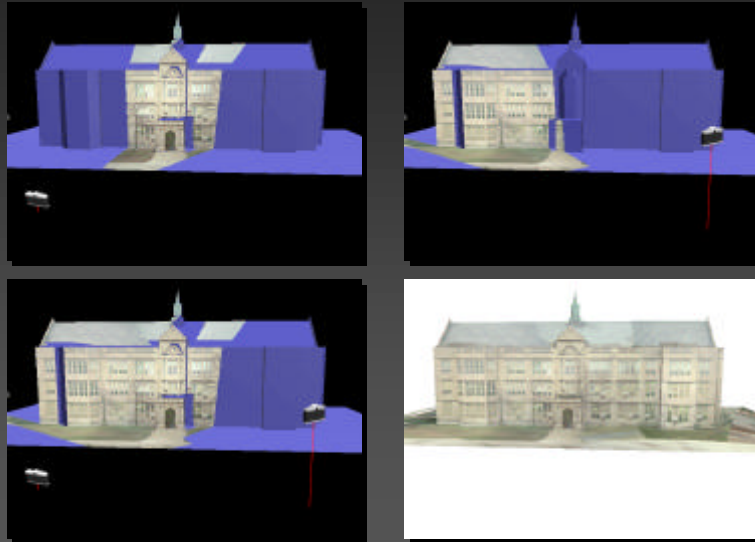
Chris Bregler

Stanford University

François Sillion

iMAGIS - GRAVIR/IMAG

Rendering with Projective Texture Mapping

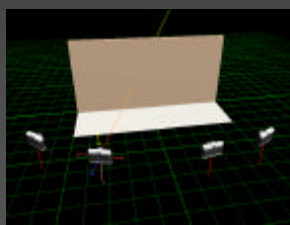


View-Dependent Weighting
Function



Scene with Geometric Detail

Model-Based Stereo



Approximate Block Model

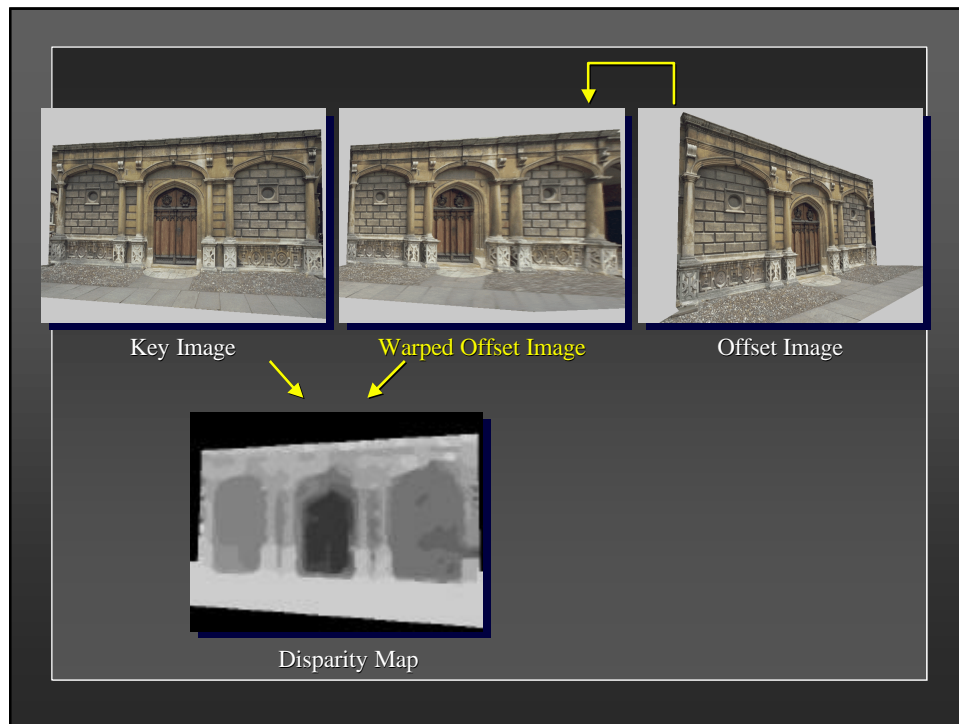
Model-Based Stereo

Given a key and an offset image,

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

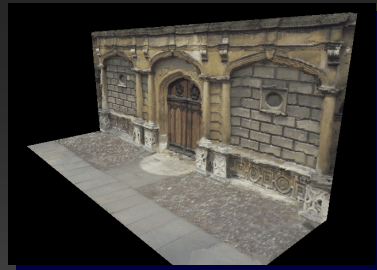
Stereo becomes feasible between key and warped offset images because:

- Disparities are small
- Foreshortening is greatly reduced



Synthetic Views of Refined Model

Four images composited with
Model-Based Stereo and
VDTM





Video

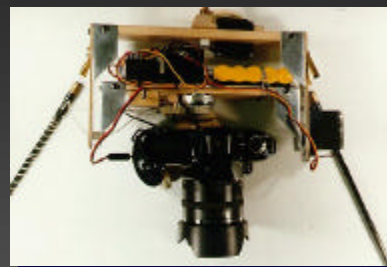
Application: The Campanile Movie

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

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

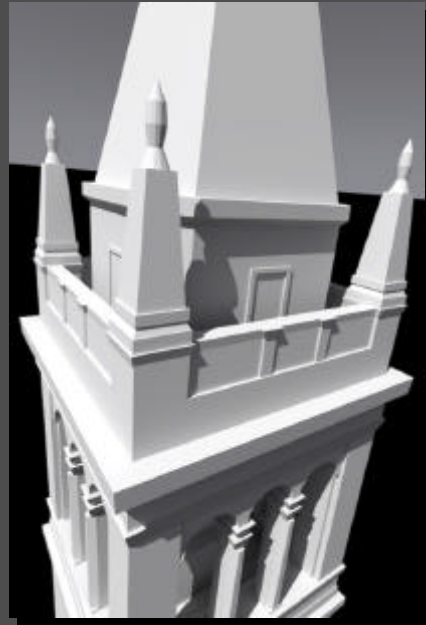


<http://www-archfp.ced.berkeley.edu/kap/>

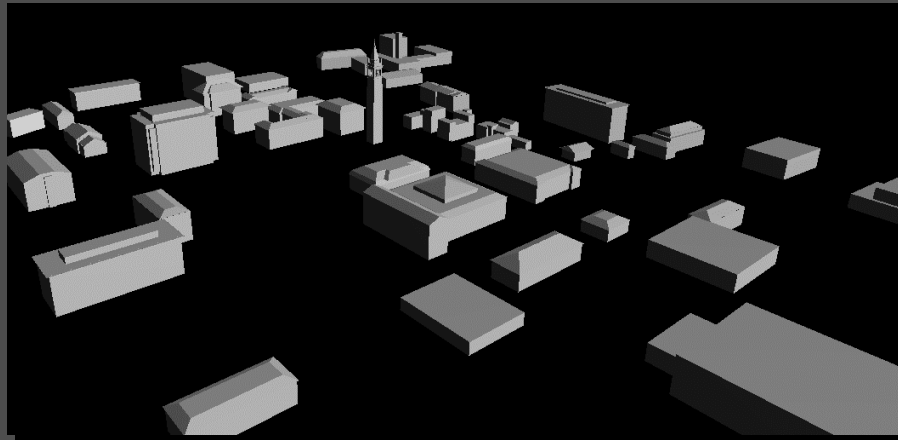


Tower Photographs

Campanile Model



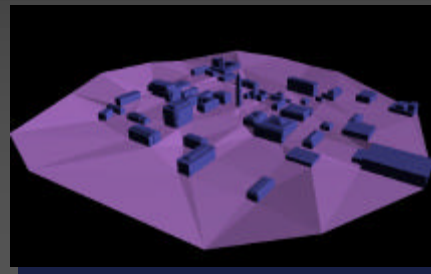
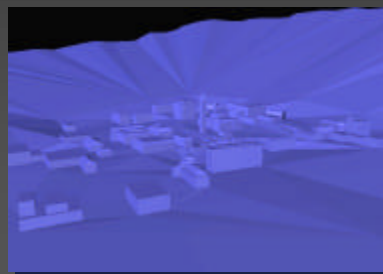
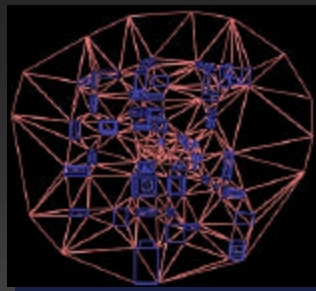
Environment Photographs



Campus Model (Campanile + 40 buildings)

Terrain Modeling

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



Video



Comparison: Time-of-flight Laser Scanning

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



Application: The Matrix



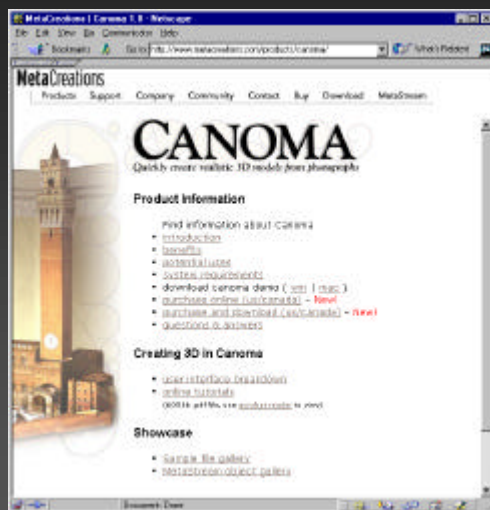
www.mvfx.com

Courtesy of
George Borshukov
and John Gaeta,
MANEX
Entertainment



Video

Commercial Product: Metacreations Canoma

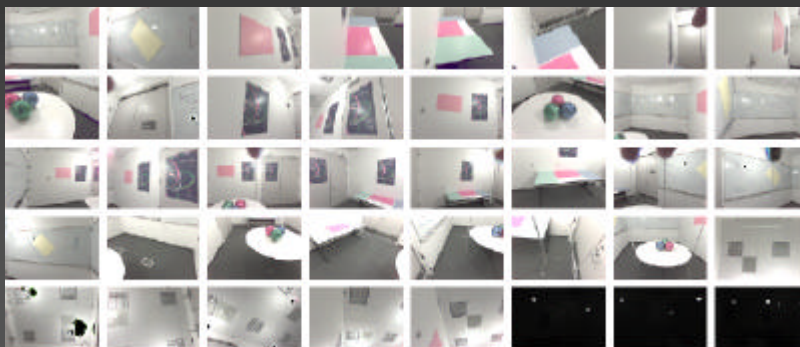


www.metacreations.com/canoma

Application: Inverse Global Illumination

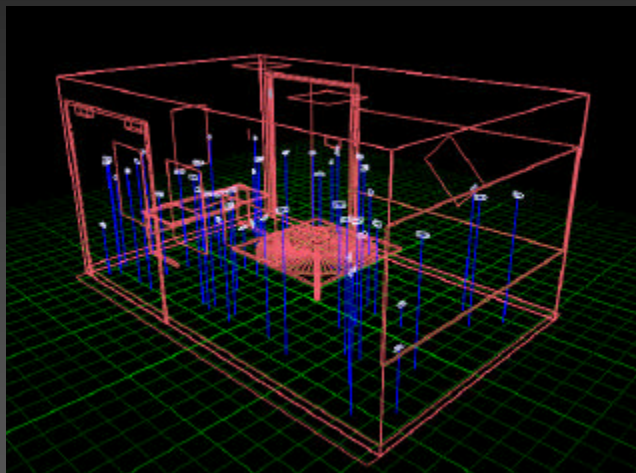
Yizhou Yu, Paul Debevec, Jitendra Malik, Tim Hawkins

SIGGRAPH 99, Thursday, 11:50-12:15pm, West Hall A



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

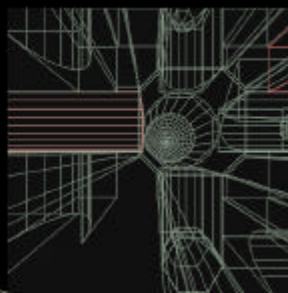
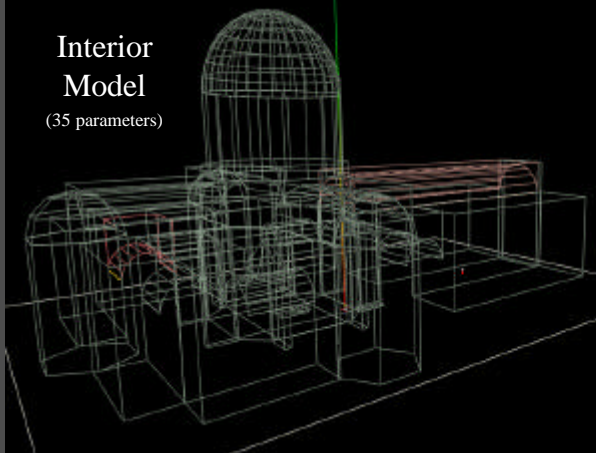


Interior Illumination Model St. Peter's Basilica



Interior Model

(35 parameters)



Related Sketches

The Making of "Fiat Lux"

Wednesday 11 August, 5:25pm - 6:00pm, Room 151 / 152

Image-Based Modeling, Rendering, and Lighting in "Fiat Lux"

Friday 13 August, 11:40am - 12:15pm, Room 408AB

Thanks

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