EN193-S08 3D Photography

http://www.lems.brown.edu/~taubin/en193s08

CLASS WILL MEET IN B&H-092 MULTIMEDIA ROOM

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Overview

- What is 3D Photography ?
- What are we going to do in this class ?
- Homework and Policy

"Analog" 3D photography !

- "3D stereoscopic imaging"
  - been around as long as cameras have
  - Use camera with 2 or more lenses (or stereo attachment)
  - Use stereo viewer to create impression of 3D

Motivation

- Digitizing real world objects
- Getting realistic models

humans

objects

places

3D Photography : Definition

- Sometimes called “3D Scanning”
- Use cameras and light to capture the shape & appearance of real objects
- Shape == geometry (point sampling + surface reconstruction + fairing)
- Appearance == surface attributes (color/texture, material properties, reflectance)
- Final result = richly detailed model

Applications in Industry

- Human body / head / face scans
  - Avatar creation for virtual worlds
  - 3d conferencing
  - medical applications
  - product design
  - Platforms:
    - Cyberware RD3030
    - Others (Geomagic, Metacreations, Cyrax, Geometrix…)

More applications

- Historical preservation, dissemination of museum artifacts (Digital Michelangelo, Monticello, …)
- CAD/CAM (eg. Legacy motorcycle parts scanned by Geomagic for Harley-Davidson).
- Marketing (models of products on the web)
- 3D games & simulation
- Reverse engineering

- http://www.lems.brown.edu/vision/extra/SHAPE/

Homework and Policy

- 4 homework problem sets (15% each)
  some include programming assignments
- One final project (40%).
- Homework assignments will be published in the class web site as soon as available.
- No midterm, no final.
- No textbook. Course notes & copies of relevant papers will be handed out.
- Two or more students can collaborate on any homework, but every student is expected to hand in his/her own answers.
- Late homework penalty of 25 % up to 1 day late and 50% otherwise.
- Office hours TBD

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Scanning Michelangelo's Florentine Pietà

Fausto Bernardini
Holly Rushmeier
Joshua Mittleman
Gabriel Taubin
Visual and Geometric Computing Group
IBM Thomas J. Watson Research Center

PROJECT HIGHLIGHTS

Development of new scanning system with high res./$

- limited budget (hi res. scanner > $300,000)
- limited time to first result (order time > 3 mos.)

Development of efficient representation for interaction

- no view possible on laptop of full geometry

Development of derivative views

- not just model, but views in context, edited geometry

One of three Pietà, the others are in the Vatican and in Milan

Created by Michelangelo late in his life
1550

Michelangelo broke off pieces of the statue, repaired by Calcagni
1555-56

Placed outside, in a a basement
1562-1721

Placed in the Duomo
1721-1980

Currently in the Museum of the Duomo
Florence, Italy

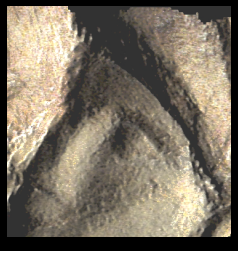
A comprehensive study by art historian Jack Wasserman

- X-rays
- View under ultraviolet
- Historical record
- Religious significance
- Digital model

- Results in book to be published by Princeton Univ. Press in year 2000

Tools we can offer

- Controlled views
- Impossible views
- Precise measurements
- Other environments
- Partial geometry
- On demand details



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Data Capture and Reconstruction

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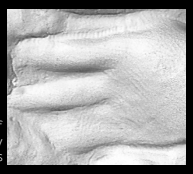
Design considerations

- Length scales
- Time constraints
- Budget

2.25m

Examine on the scale of meters to study proportion, design



0.15m

Examine on the scale of millimeters to study tool marks

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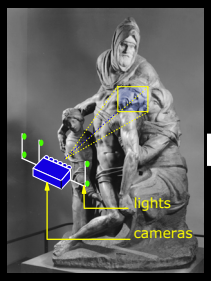
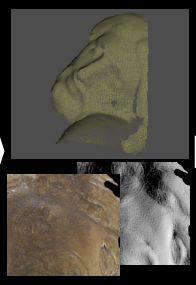
Capture and Reconstruction



Multiple digital photographs are taken



Surface shape, color and details are computed for each scan

Scans are aligned and merged

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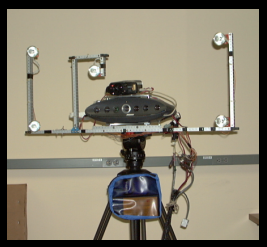
Pietà data capture

- 3 trips (Feb 98, June 98, July 99)
- 800+ scans
- 9600 digital pictures
- 2 minutes per scan
- 10,000 points per scan (20x20cm) from structured light system
- 2mm intersample distance (25 samples/cm^2)
- 0.5mm intersample distance (400 samples cm^2) from photometric system



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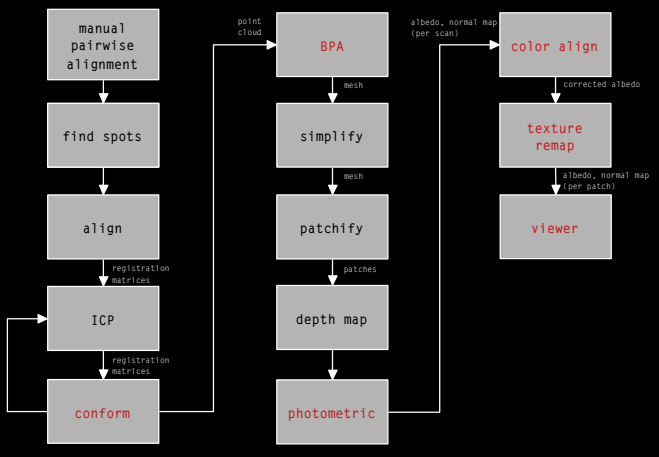

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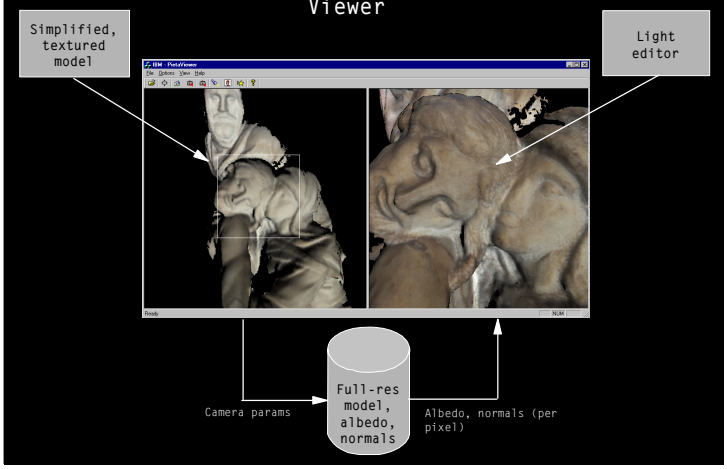
Interactive Viewer



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manual pairwise alignment

find spots

align

registration matrices

ICP

registration matrices

conform

point cloud

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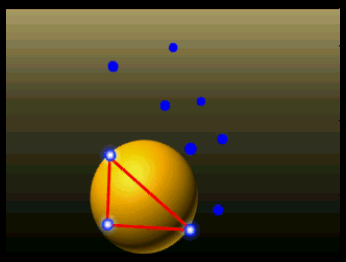
Ball Pivoting Algorithm

- A ball "walks" over the point cloud, creating a triangle for every three points it touches
- Interpolating triangle mesh
- Linear-time algorithm
- Robust
- Easy to implement

Results

- Real data: Pietà, Stanford repository
- Generates 1M triangle mesh in 3 minutes on a PC
- Out-of-core implementation, Pieta' (13M tris) is meshed in 40 mins on a Pentium II PC with 256MB of RAM



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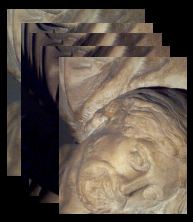
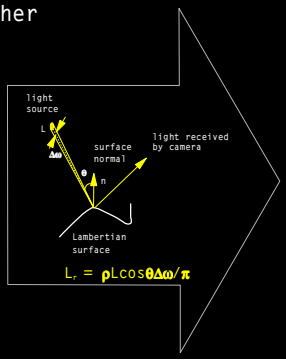
Photometric Processing

Computing colors and normals that are consistent with underlying geometry and with each other



color images for five light positions



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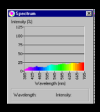
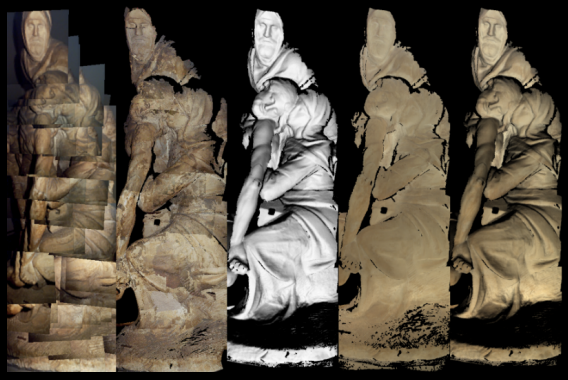


Color alignment



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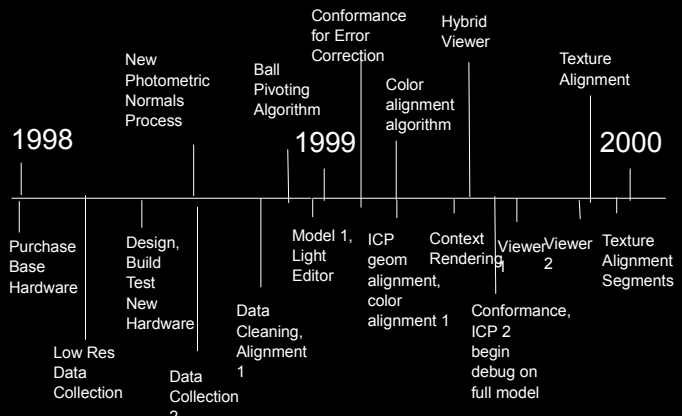
Texture remapping

INVENTIONS



DEVELOPMENT/DEBUGGING


Photographs
of the
Statue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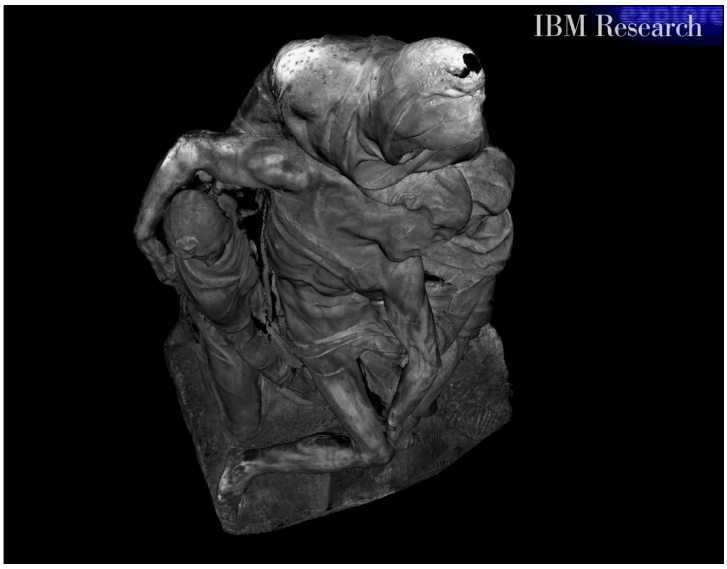
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Design and Implementation of a 3D Digital Camera

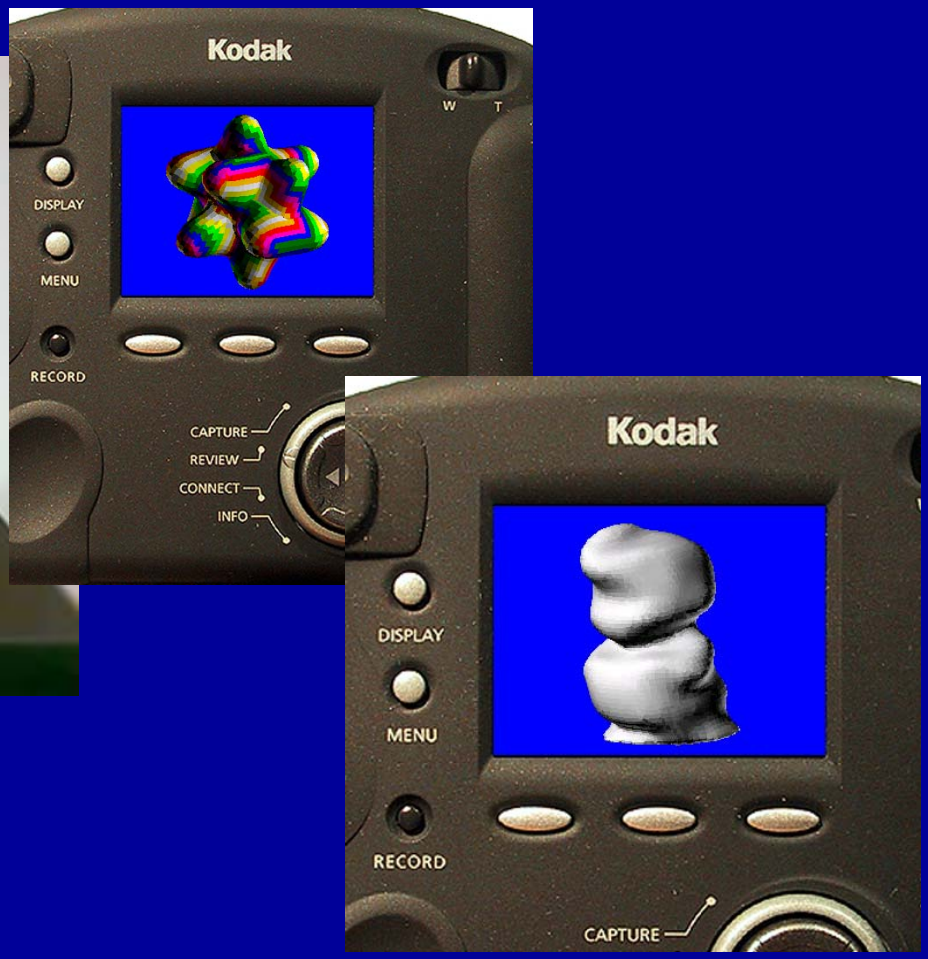
Gabriel Taubin
IBM T.J. Watson Research Center
Andrew Homyk, Silvio Savarese
CalTech

The Gadgets Lab @ CalTech

Many consumer electronics gadgets, such as PDAs, digital cameras, MP3 players and cellphones, have powerful microprocessors and memory so that they may be reprogrammed to perform tasks other than those the devices have been designed for.

3D Digital Camera

DEMO !

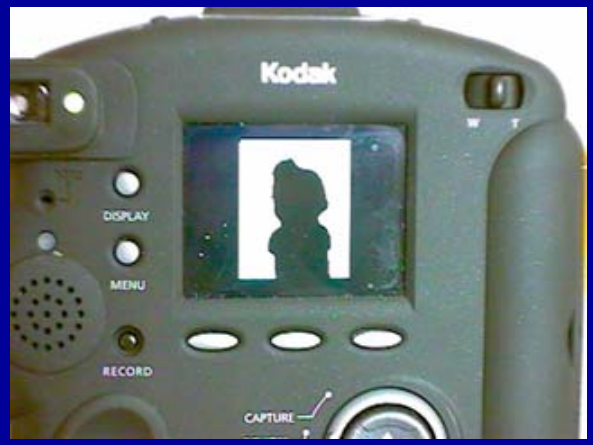


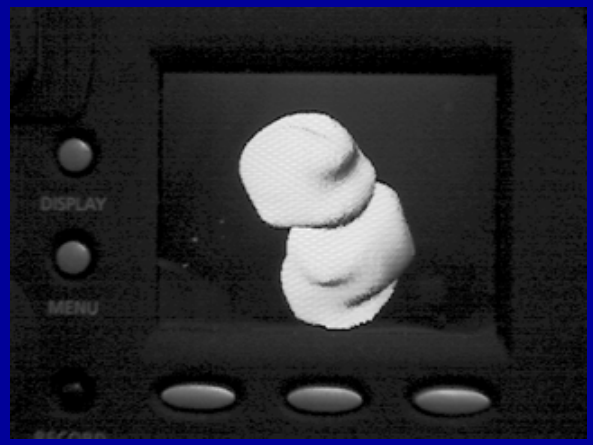
- Capture Mode
- Viewer Mode

Kodak DC290 / Features

- 2.1 Mpix CCD
- IrDA / USB / Serial ports
- Microphone
- Speaker
- TFT color display
- 66 MHz PowerPC processor
- Hard Disk (CF-I)
- DigitaOS operating system
- Product released in 98-99

3D Digital Camera





3D Digital Camera / Capture Mode

- ALL the computation done in the camera
- Volume Carving
- Turntable Control
- Isosurface Extraction
- Mesh
- Recover Color/Texture
- 3D Compress
- Save to Disk

3D Digital Camera / Viewer Mode

- Open file
- Parse VRML
- Decompress MPEG-4 mesh
- Interactive 3D software rendering
- All VRML property bindings and shading modes supported

3D Viewer

PocketPC

IBM Hotmedia (Java)

Palm OS