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...)

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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
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 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
Data Capture and Reconstruction

Capture and Reconstruction

Multiple digital photographs are taken

Surface shape, color and details are computed for each scan

Scans are aligned and merged

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)
- 0.5mm intersample distance (400 samples cm) from photometric system

Design considerations

- Length scales
- Time constraints
- Budget

Design considerations on the scale of meters to study proportion, design

Design considerations on the scale of millimeters to study tool marks

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Ball Pivoting Algorithm

- A ball "walks" over the point cloud, creating a triangle for every three points it touches
- 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, Pietà (13M tris) is meshed in 40 mins on a Pentium II PC with 256MB of RAM

Photometric Processing

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

Color alignment

Light, normal, surface normal, light captured by camera

L = \rho \cos \theta \Delta \omega

Color alignment algorithm

Conformance for Error Correction

Hybrid Viewer

Texture remapping

1998

New Photometric Normals Process

Ball Pivoting Algorithm

1999

Model 1, Light Editor

Color alignment algorithm

2000

Data Cleaning, Alignment

Context Renderer

Conformance, ICP 2 begins debug on full model

DEVELOPMENT/DEBUGGING
Photographs of the Statue

2-19-24
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

- 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

IBM Hotmedia (Java)
Palm OS

PocketPC

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