3D Digitization at Indiana University and Beyond
3D Digitization – How?  (Choosing between techniques)

- **3D Need**
  - Digitize?
  - Surface Only?
  - Photogrammetry?
  - Photogrammetry Workflow (handheld, turntable, drone)
  - Post-processing
  - Metadata / Archiving / Dissemination

- **Digitization Techniques**
  - **3D Scanning** (GoScan, LIDAR, or Matterport)
    - Size, detail, material, etc. (20%)
  - **Volume Scan** (CT, microCT, MRI, etc.)
    - Interior data required (5%)
  - **3D Model (by hand)**
    - Measure, sketch, photos (10%)

- **Uses**
  - Digital Preservation
  - Research & Scholarship
  - Teaching & Learning
  - Public Outreach
Hardware-Based 3D Scanning
Understanding the Limitations

- Hardware Scalability
- Limited Color
Software-based Photogrammetry

• A method for extracting three-dimensional (3D) models or measurements of an object, environment, or terrain from a set of standard two-dimensional (2D) photographs

• Applicable to a broad range of academic disciplines, including cultural heritage, architecture, paleontology, and geospatial

• Results in high computational complexity and large data sizes
Photogrammetry – General Workflow

Life-size bronze statue (by Tuck Langland)

300+ photographs capturing all angles and details

Texture-mapped 3D model

Photogrammetry & 3D post-processing workflows

SfM

Mesh

Texture
Photogrammetry – A word about photography

• Supports many types of cameras & rigs

• Key issues:
  – Quality
  – Coverage
  – Consistency
  – Lighting
  – Background

• Can work with video and integrate depth image data
Photogrammetry for Surface Reconstruction

• Capture series of 2D images
• Use structure from motion techniques to extract 3D surface points

www.wur.nl
3D Digitization Workflow

(by E. Wernert; adapted from IU MDPI Workflow)
Scalable Photogrammetry

Why HPC for Photogrammetry?
- Algorithm complexity → hours-days of computation for small-medium photo sets; weeks for larger data sets on a good workstation

Coordinates:
- \((X, Y, Z)\) - point in the local camera space
- \((u, v)\) - projected point in the image plane
- \(w, h\) - image width and height

Camera:
- \(f\) - focal length
- \(cx, cy\) - principal point offset
- \(K_1, K_2, K_3, K_4\) - radial distortion coefficients
- \(P_1, P_2, P_3, P_4\) - tangential distortion coeffs
- \(B_1, B_2\) - affinity and non-orthogonality coeffs

Solve these systems of equations for every point on every photos in photo set:
- \(x = X / Z\)
- \(y = Y / Z\)
- \(r = \sqrt{x^2 + y^2}\)
- \(x' = x(1 + K_1 r^2 + K_2 r^4 + K_3 r^6 + K_4 r^8) + (P_1 (r^2 + 2x^2) + 2P_2 xy) (1 + P_3 r^2 + P_4 r^4)\)
- \(y' = y(1 + K_1 r^2 + K_2 r^4 + K_3 r^6 + K_4 r^8) + (P_2 (r^2 + 2y^2) + 2P_1 xy) (1 + P_3 r^2 + P_4 r^4)\)
- \(u = w * 0.5 + cx + x'f + x'B1 + y'B2\)
- \(v = h * 0.5 + cy + y'f\)
Scalable Photogrammetry

Large spaces & datasets → large number of photos, many pixels per photo

Architectural Interiors & Exteriors (Matthew Brennan) → ~300-1000+ photos each

Monte Albán Geophysical Archaeology Project (Alex Badillo) → 14,000+ photos → ~30 compute hours
Scalable Photogrammetry

- Getty Center Model
  - 296 images
  - 3.5 GB

- Antefix
  - 415 images
  - 4.3 GB

- Angel Mounds Historic Site
  - 1703 images
  - 37.5 GB
Photogrammetry Processing – Steps

1. Align photos & generate point cloud
2. Build dense point cloud
3. Build mesh
4. Build texture
Comparing Run Times

- Carbonate High Performance Computer at Indiana University
  - 256 GB of RAM per node, scripted to run on 4 nodes
- Google Cloud Virtual Machine
  - 256 GB of RAM and 4 GPUs
- Getty VFX Machines
  - 512GB of RAM and 5 GPUs

All files run at IU transferred using Globus, a high-performance GridFTP service designed for secure data movement between networked endpoints.
VFX, HPC, and Virtual Machine Comparison

Chart Title

- GC model, 296
- Antefix, 415
- Flat Wood, 535
- Frame, 785
- Angel Mounds, 1700

VFX, HPC, VM
## Comparison Breakdown

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3D Digitization Workflow

(by E. Wernert; adapted from IU MDPI Workflow)
Covid-19, Now What? Virtual Tours

Bicentennial Traveling Exhibit

Center for Ray Bradbury Studies

Herron Basile Gallery

Herron Marsh Gallery
Thank you!

For questions or more information:

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