Global Non-Rigid Alignment

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3-D Scanning Pipeline

- Acquisition

Scanners acquire data from a single viewpoint
3-D Scanning Pipeline

- Acquisition
- Alignment
3-D Scanning Pipeline

- Acquisition
- Alignment
- Merging
Iterative Closest Points [Besl92]

- To fit two meshes, need correspondence between points
  - Assume points correspond to closest points on other mesh
  - Compute best fit on a subset of all points
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- If starting point was good, result should be better
  - Iterate until fit converges to minimum error
Range Scanning: Calibration Error

[Levoy00] Courtesy Paul Debevec
Range Scanning: Calibration Error

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Range Scanning: Calibration Error

[Levoy00] Courtesey Paul Debevec

Mechanical Distortion

0 mm  2 mm
Goal: Multi-Scan Non-Rigid Alignment

We desire an algorithm that will:

- Prevent artifacts in merging
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We desire an algorithm that will:

- Prevent artifacts in merging
- Distribute error evenly
- Preserve detail without introducing new warp
- Be practical, efficient, and parallelizable for large datasets

David's head comprises 1400 scans and 230 million vertices
Global Alignment Pipeline

Pairwise Correspondences
Global Alignment Pipeline

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Pairwise Correspondences
Global Alignment Pipeline

Pairwise Correspondences → Global Feature Positioning
Global Alignment Pipeline

Pairwise Correspondences  Global Feature Positioning
Global Alignment Pipeline

Pairwise Correspondences → Global Feature Positioning → Optimize Global Positions
Global Alignment Pipeline

- Pairwise Correspondences
- Global Feature Positioning
- Optimize Global Positions
- Warp Scans
Results: David's Head

- 1400 range scans
- 230 million points

Correspondences
- 78 hours CPU time
  - 1.5 hours wall time

Positioning and Alignment
- 30 minutes CPU time
Results: David's Head

Rigid

Non-Rigid
Results: David's Head

Rigid

Non-Rigid

Wednesday, August 19, 2009
Results: David's Head

Rigid

Non-Rigid
Results: Awakening

1836 scans, 390 million vertices
Correspondences: 51.5 CPU hours
Alignment: 1 CPU hour
Results: Awakening

1836 scans, 390 million vertices
Correspondences: 51.5 CPU hours
Alignment: 1 CPU hour
Results: Forma Urbis Romae #033

Rigid

140 scans, 71 million vertices; Correspondences: 48 hours; Alignment: 27 minutes
Results: Forma Urbis Romae #033

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Non-Rigid

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Non-Rigid

140 scans, 71 million vertices; Correspondences: 48 hours; Alignment: 27 minutes
Summary

- Consistently align all pairs of scans to each other
- Scalability: never more than two scans in memory
- Compensates for calibration error and slight deformations
- Supports rigid alignment too: just restrict to rigid transforms

- Code: www.cs.princeton.edu/~bjbrown