A Laser Range Scanner Designed for Minimum Calibration Complexity

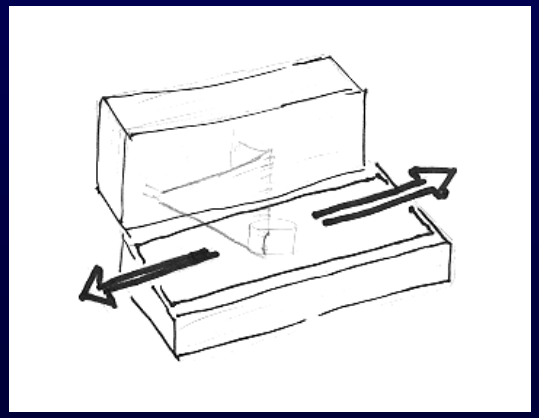
James Davis, Xing Chen

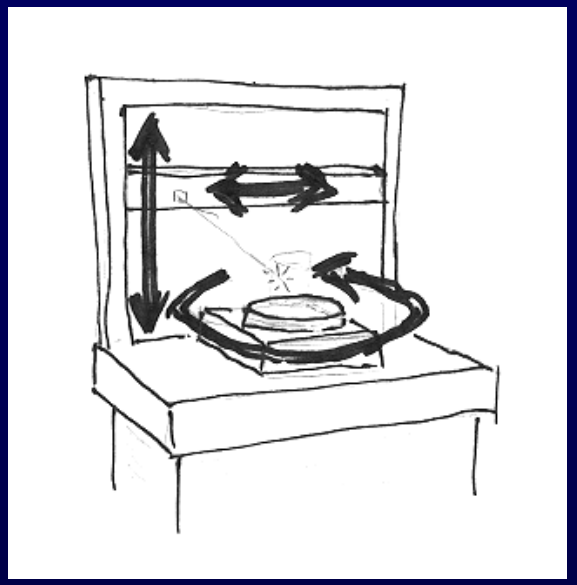
Stanford Computer Graphics Laboratory

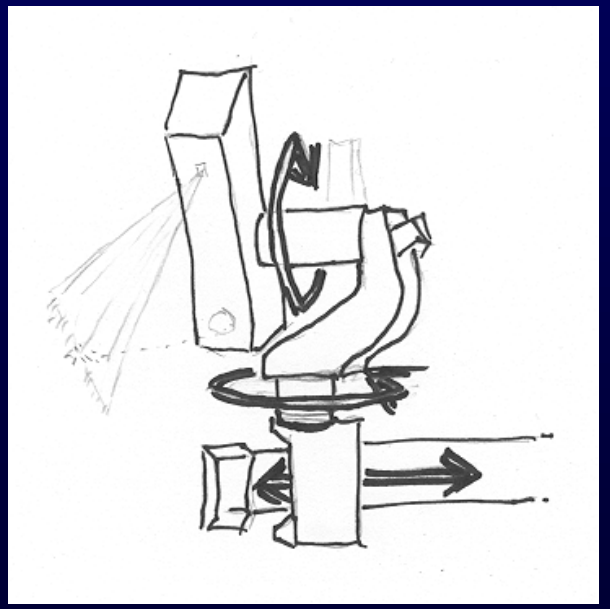
3D Digital Imaging and Modeling

3DIM 2001

Scanner Designs

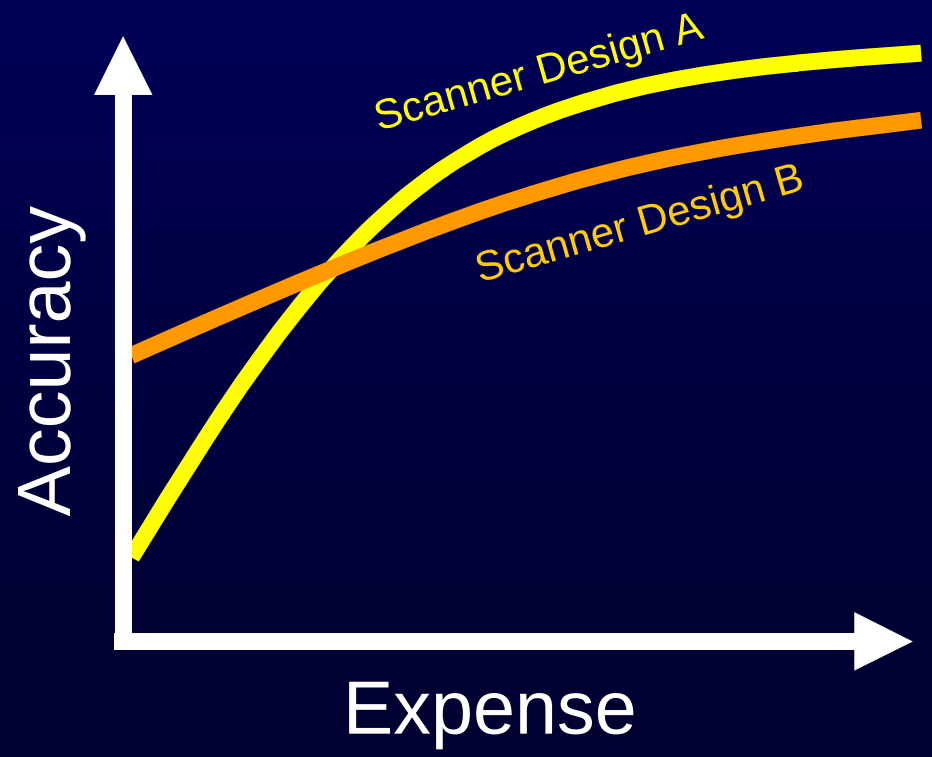






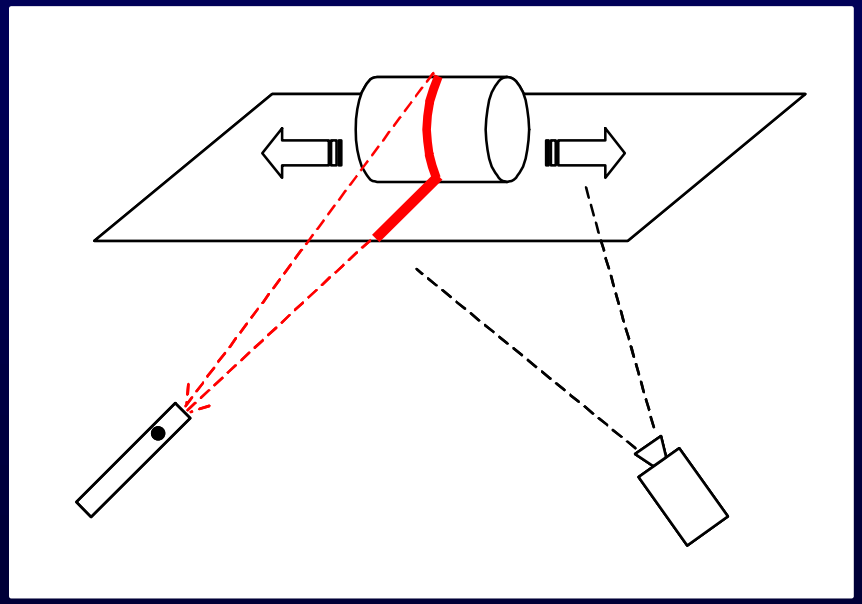
Quality Tradeoff

- Expense vs. accuracy
- Different curves possible
- Complex calibration is expensive



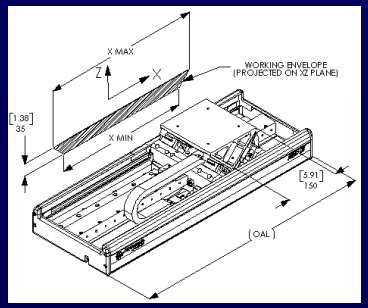
Conventional stripe scanner

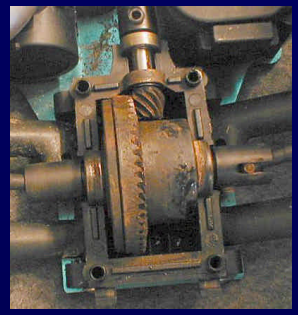
- Triangulation between camera and laser



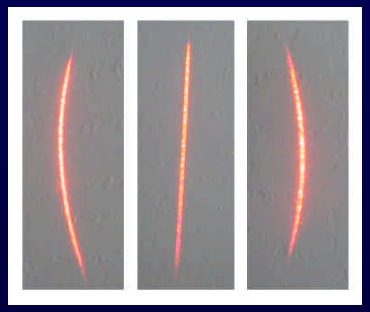
Complexities of traditional design

- Actuated components

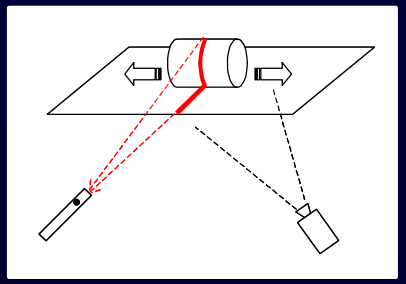




- Cylindrical lens precision

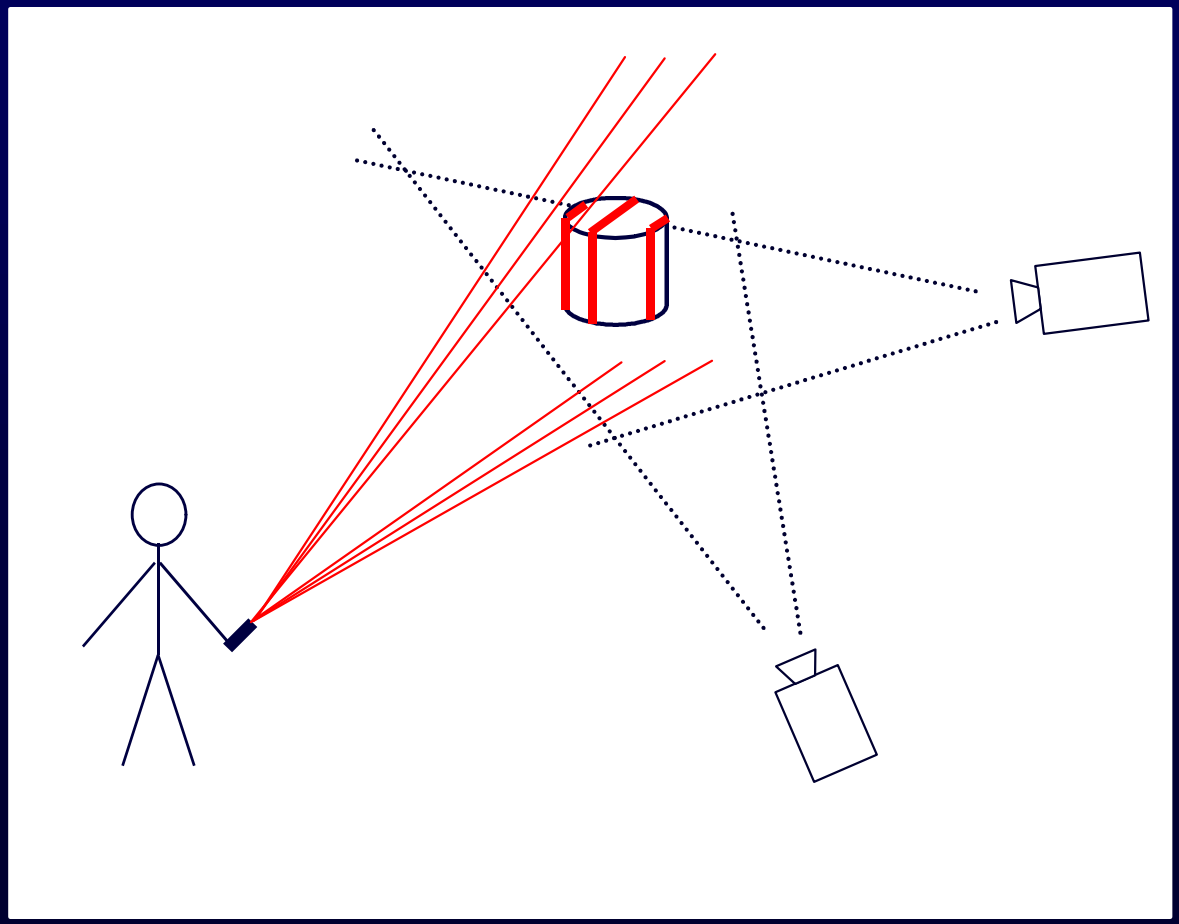


- Custom calibration procedure

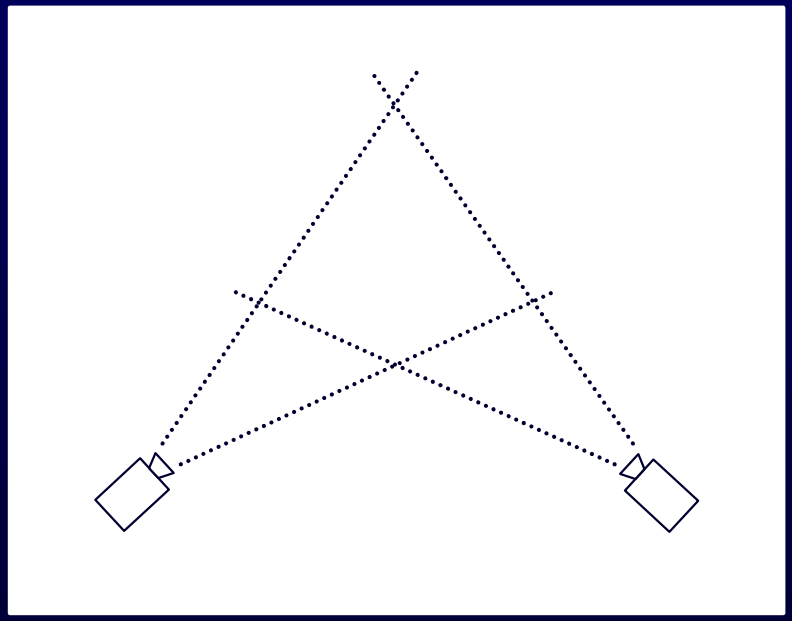


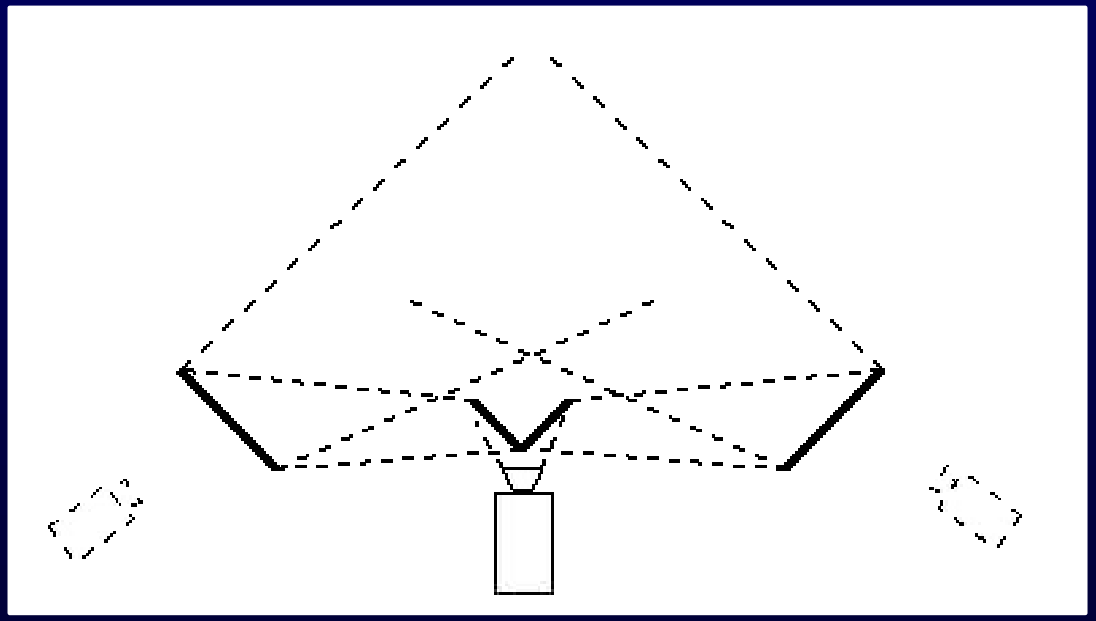
Our design

- Triangulation between two cameras
- No actuated components



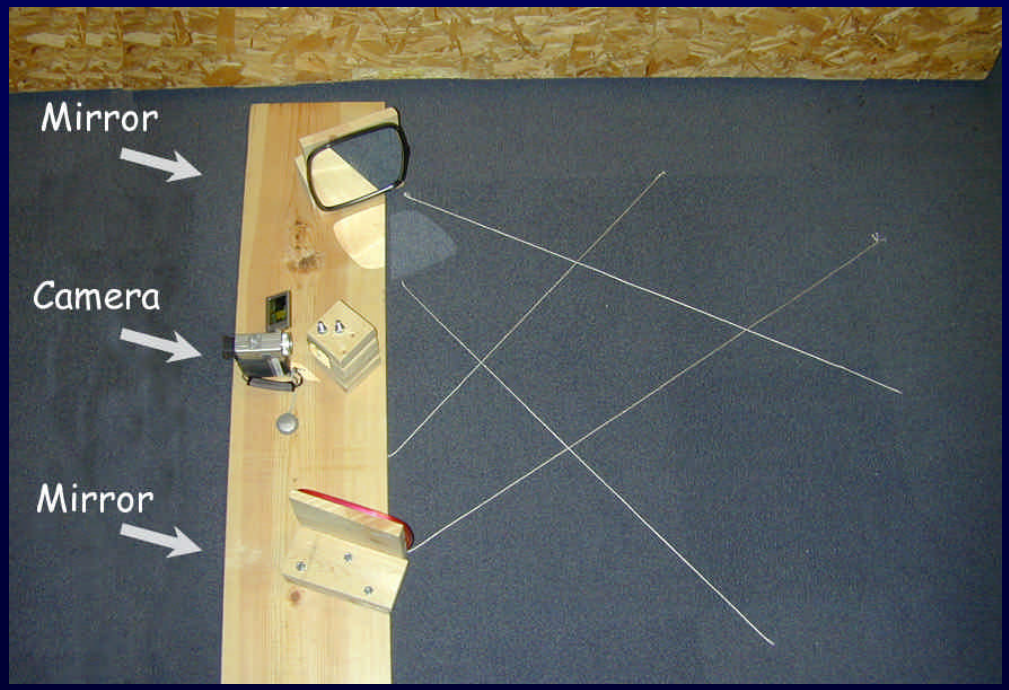
Catadioptric layout





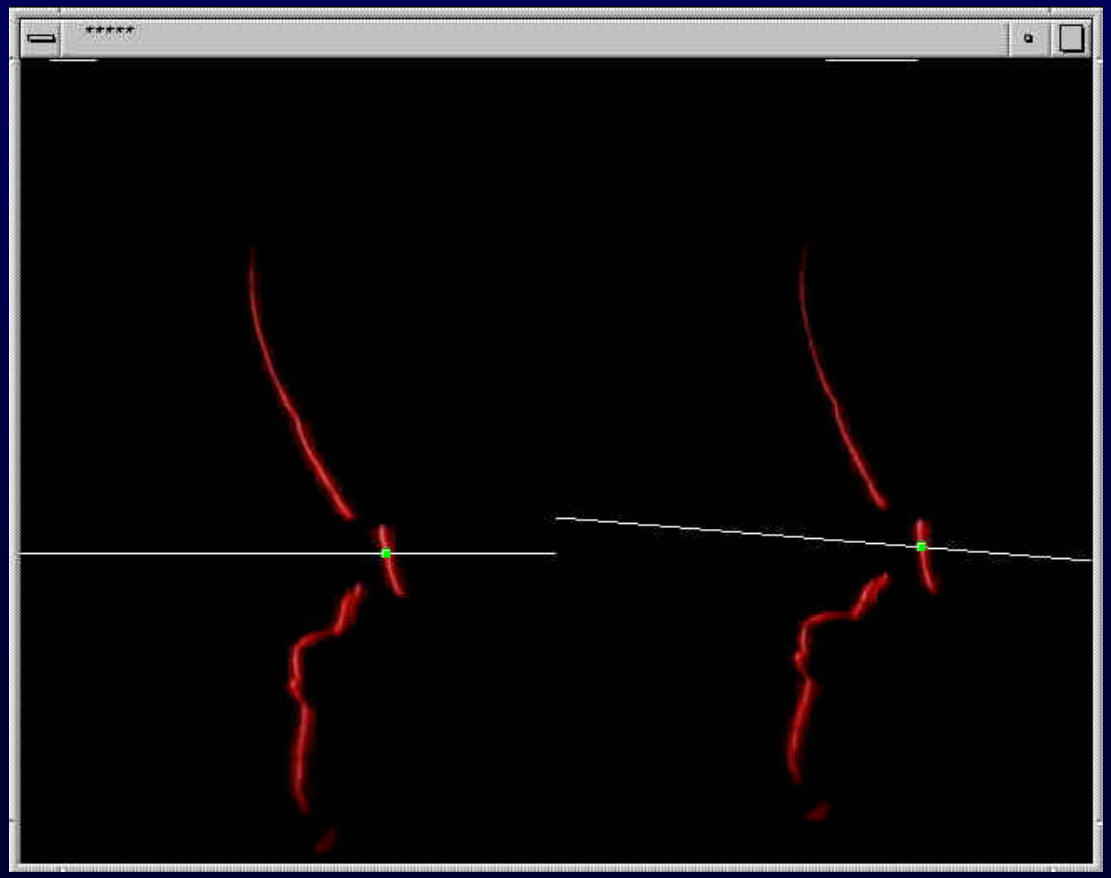
Our scanner

- **Simple components**
  - Camcorder, four mirrors, rigid mounting



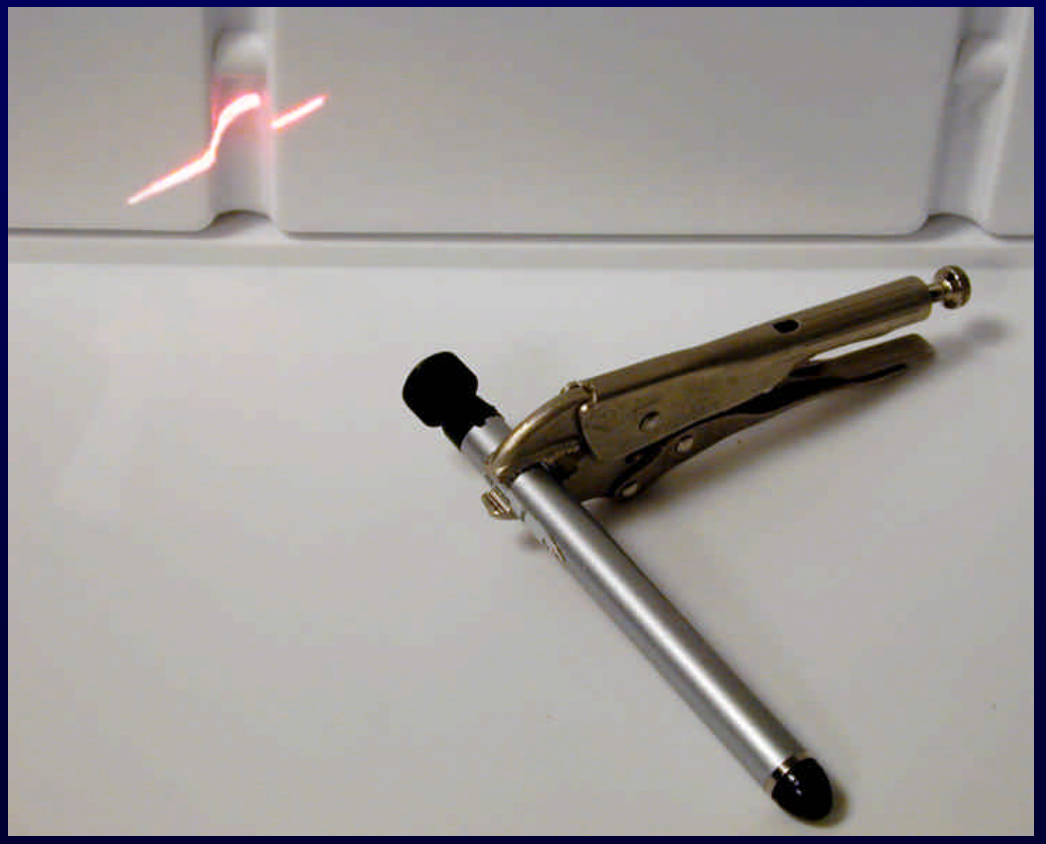
Stripe processing

- **Locate corresponding points**
  - Use epipolar constraint
  - Discard ambiguous data



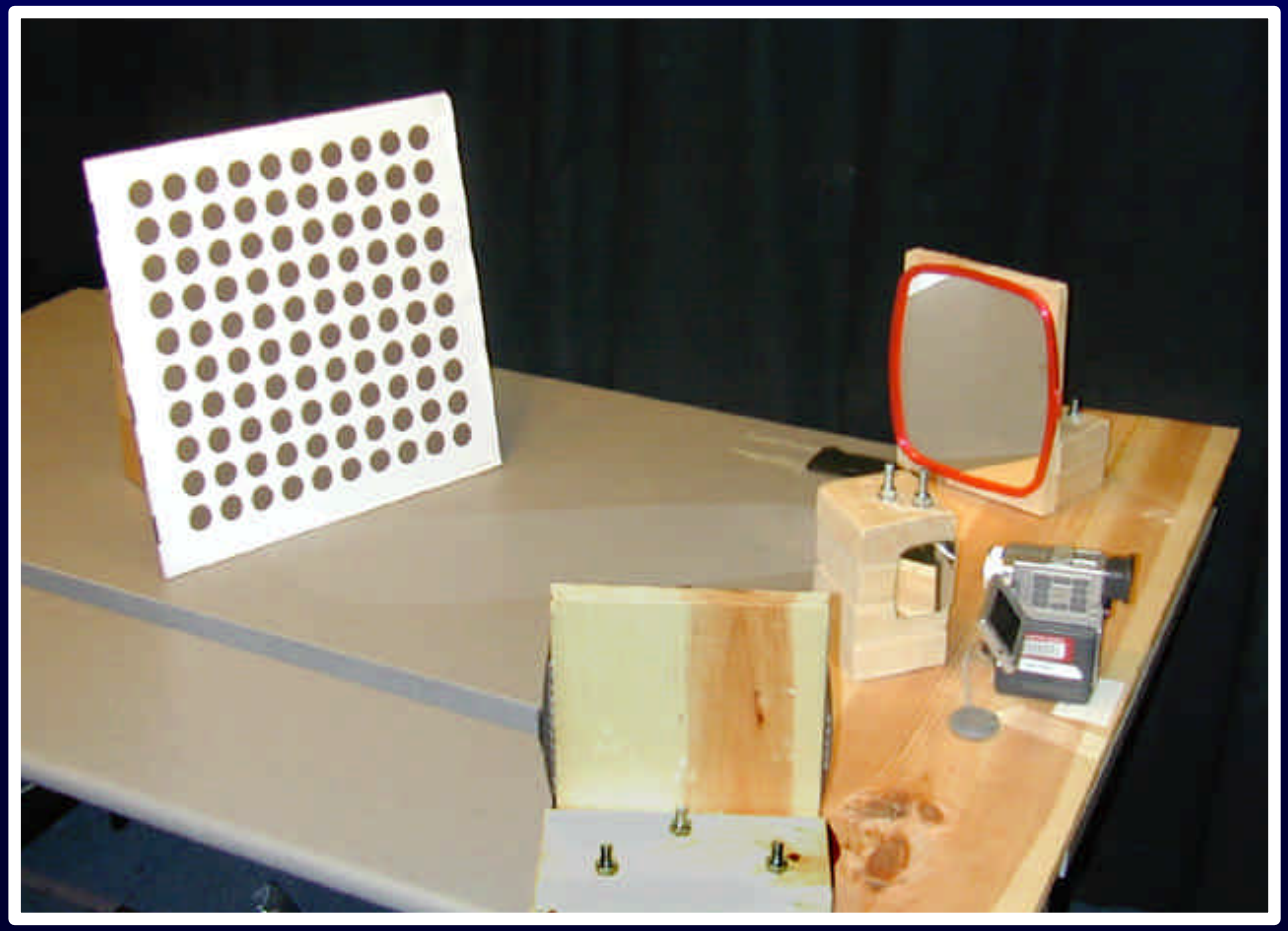
Cylindrical lens precision

- No precision mounting



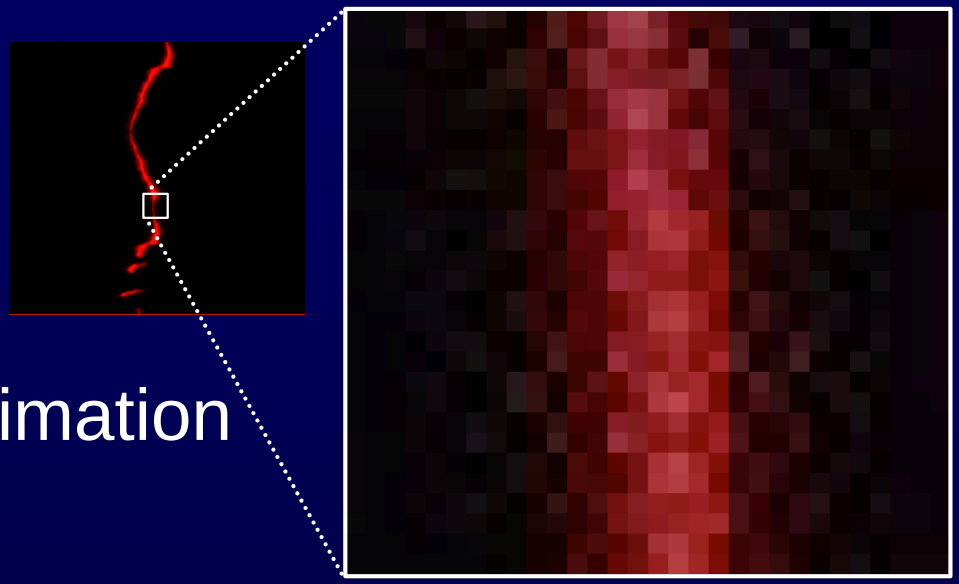
Scanner calibration

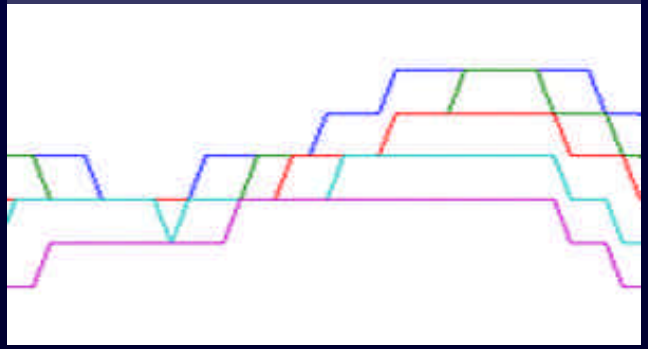
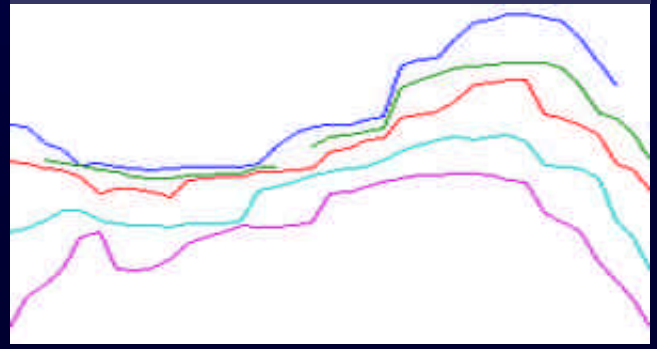
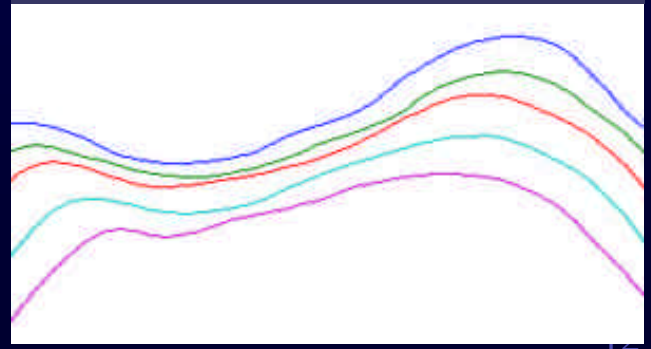
- Camera model and pose [Heikkila, Silven 97]
- Well-studied easy calibration



Peak detection

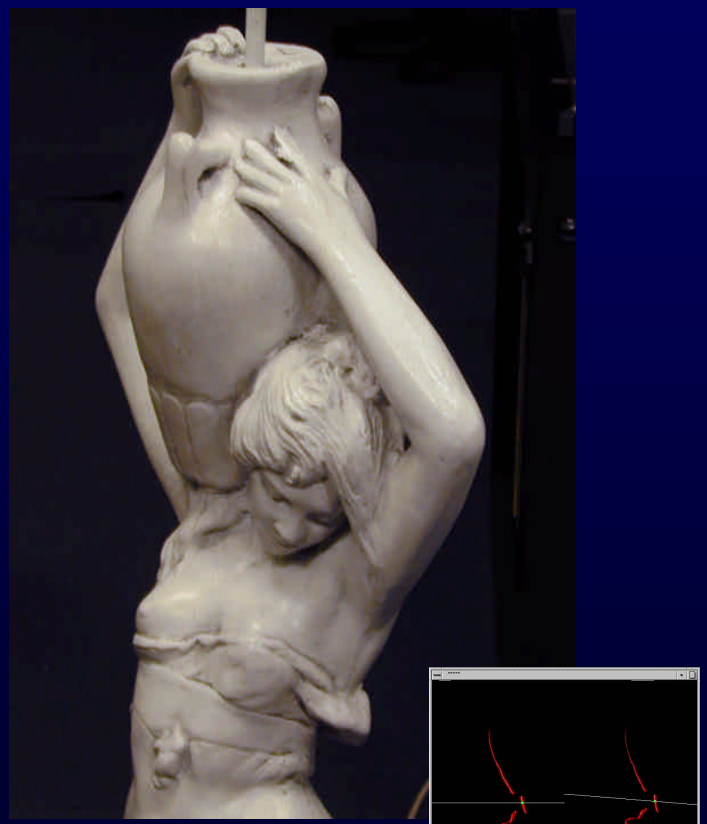
- **Filter image**
  - Video signal noise
- **Sub-pixel detection**
  - Local Gaussian approximation



Maximum intensity	Local Gaussian	Gaussian with filtering
		

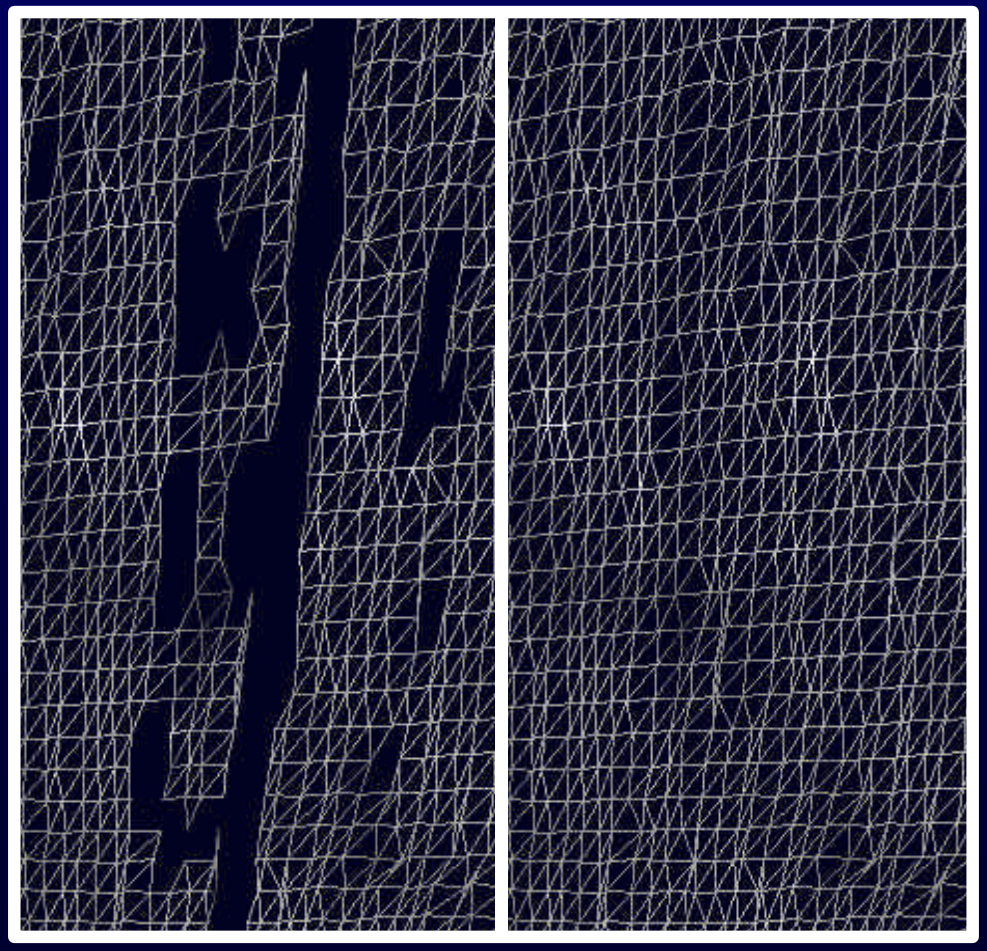
Mesh coverage

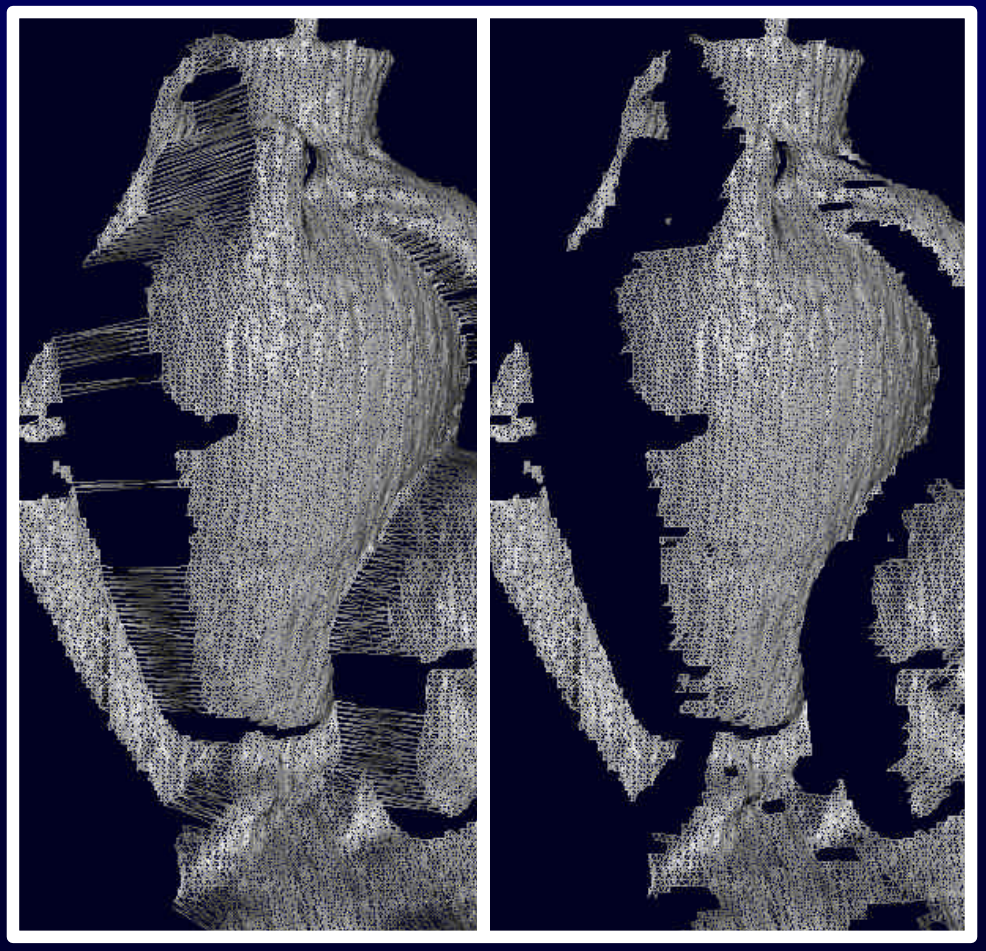
- Video sequence defines mesh
- Stripe spacing related to laser velocity



Constructing a mesh

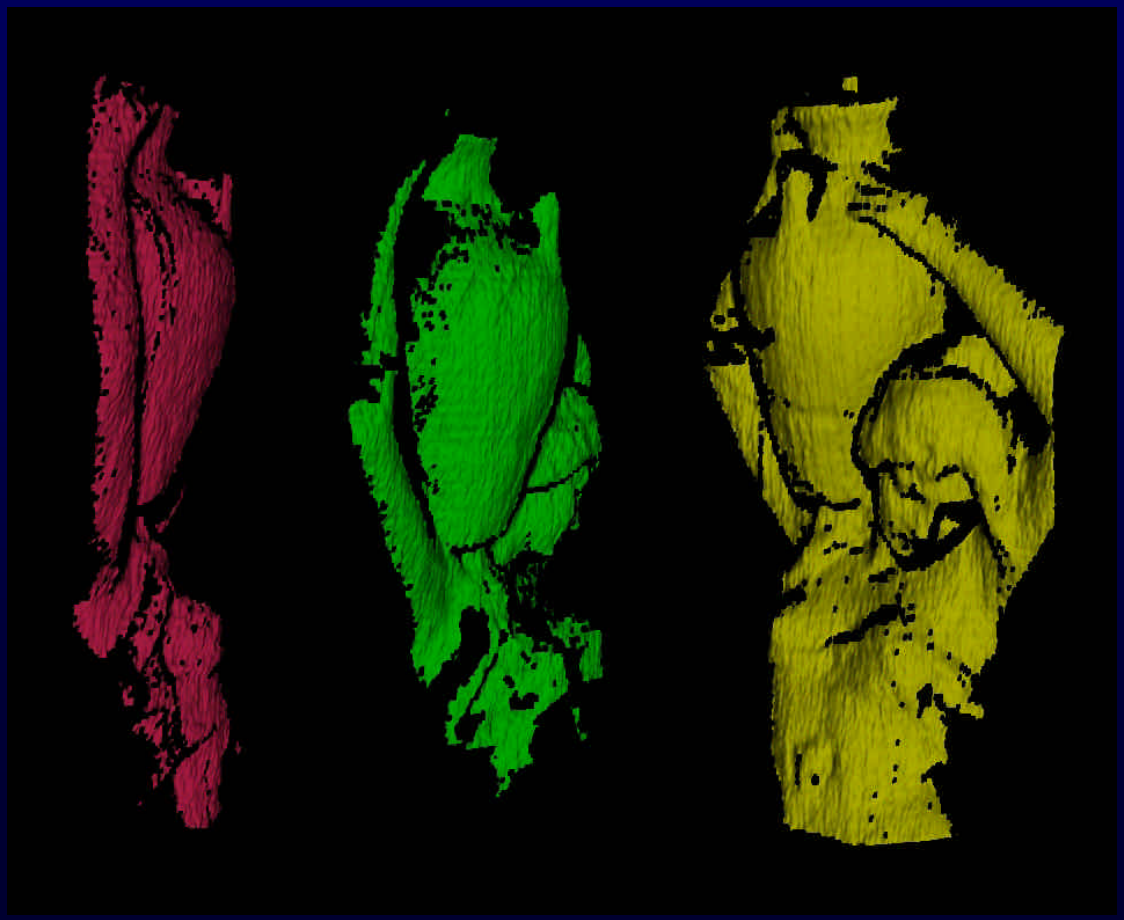
- Fill stripe sampling gaps
- Detect depth discontinuities

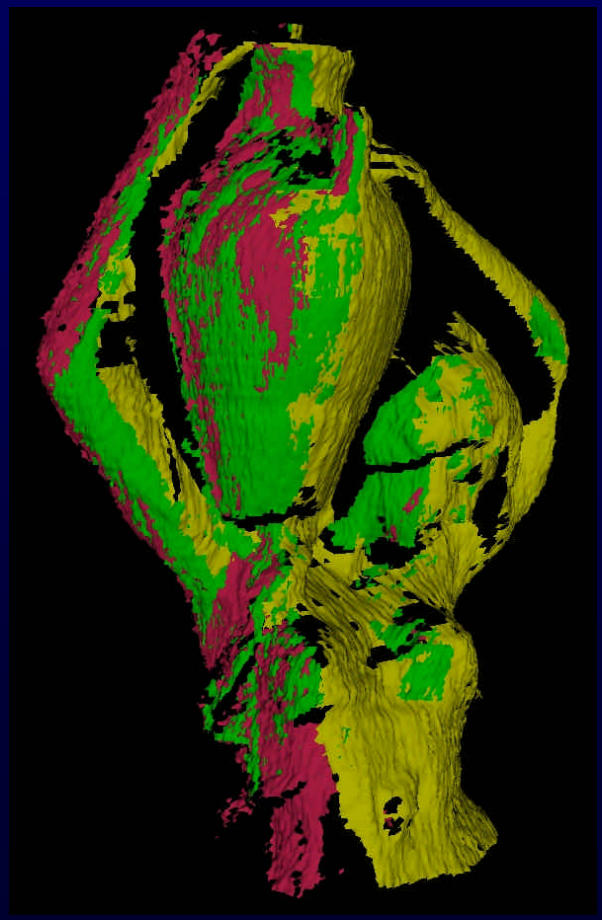




Aligning scans

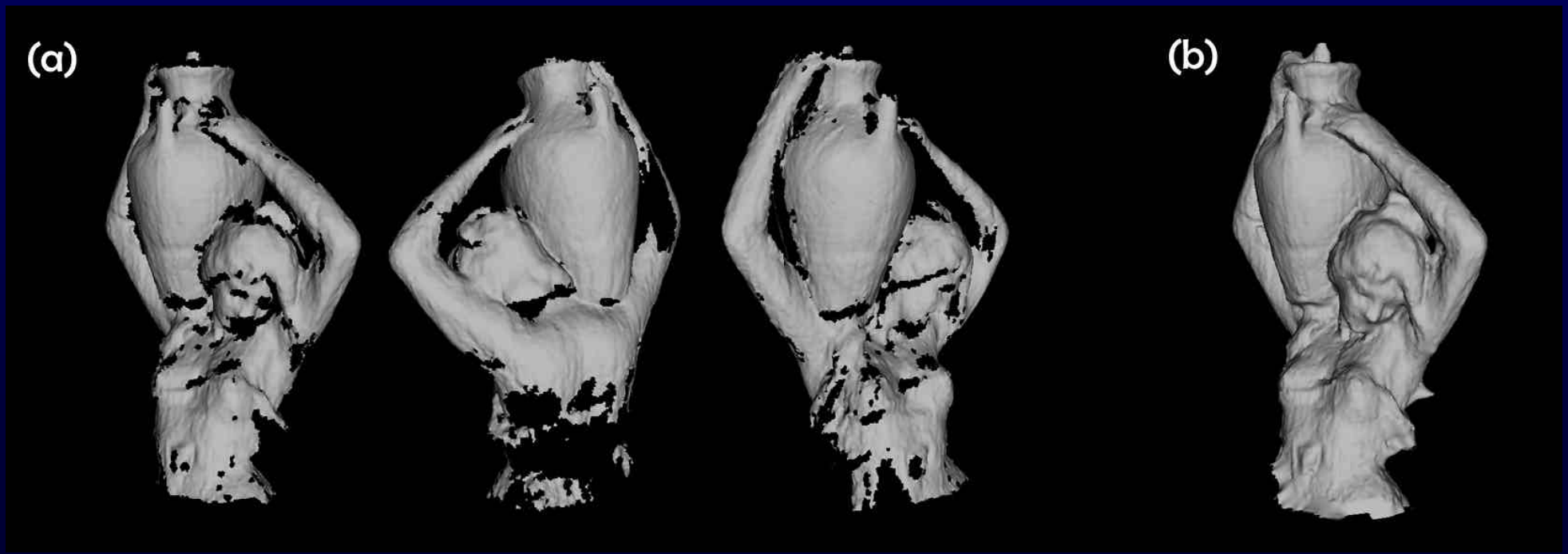
- **Iterative closest point (ICP)** [Besl, McKay - Chen, Medioni 92]
- **Global alignment** [Pulli 99]



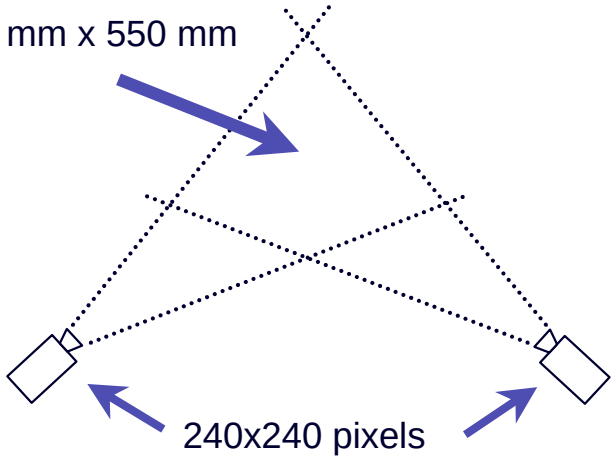


Merging scans

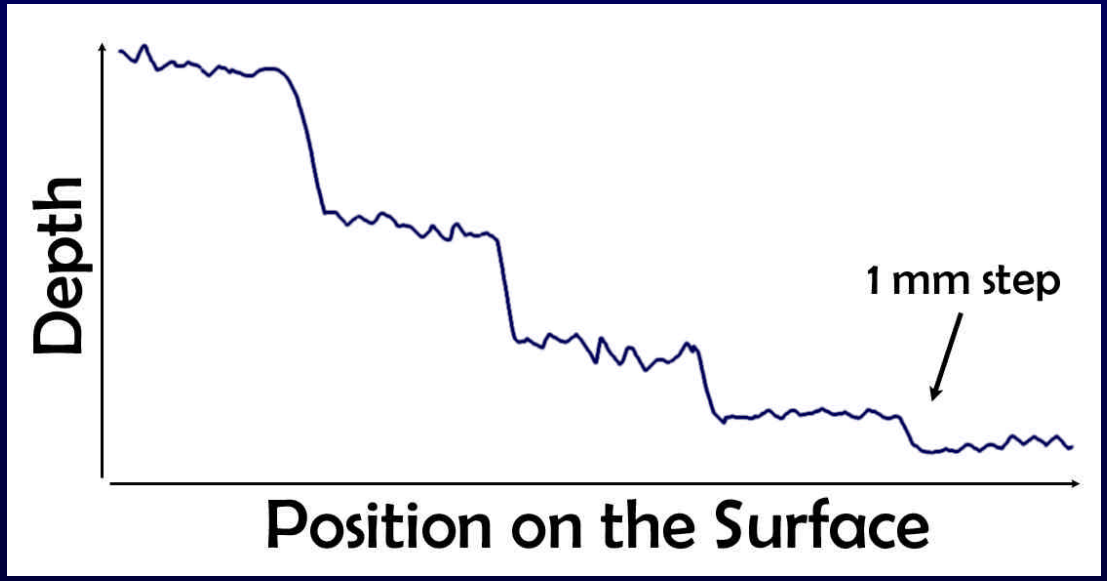
- Volumetric merging (VRIP) [Curless, Levoy 96]
- Hole filling



Depth resolution



Expected depth resolution: 1.8 mm



Conclusion

- **Minimal calibration complexity**
  - No actuated components
  - No precision lens placement
  - Well-studied easy calibration model