Acquisition

Acknowledgements: Olga Sorkine-Hornung and Daniele Panozzo

Geometry Acquisition Pipeline

Scanning: results in range images

⇨

Registration: bring all range images to one coordinate system

⇨

Stitching/ reconstruction: Integration of scans into a single mesh

⇨

Postprocess:
- Topological and geometric filtering
- Remeshing
- Compression

Geometry Acquisition Pipeline

Scanning: results in range images

⇨

Registration: bring all range images to one coordinate system

⇨

Stitching/ reconstruction: Integration of scans into a single mesh

⇨

Postprocess:
- Topological and geometric filtering
- Remeshing
- Compression

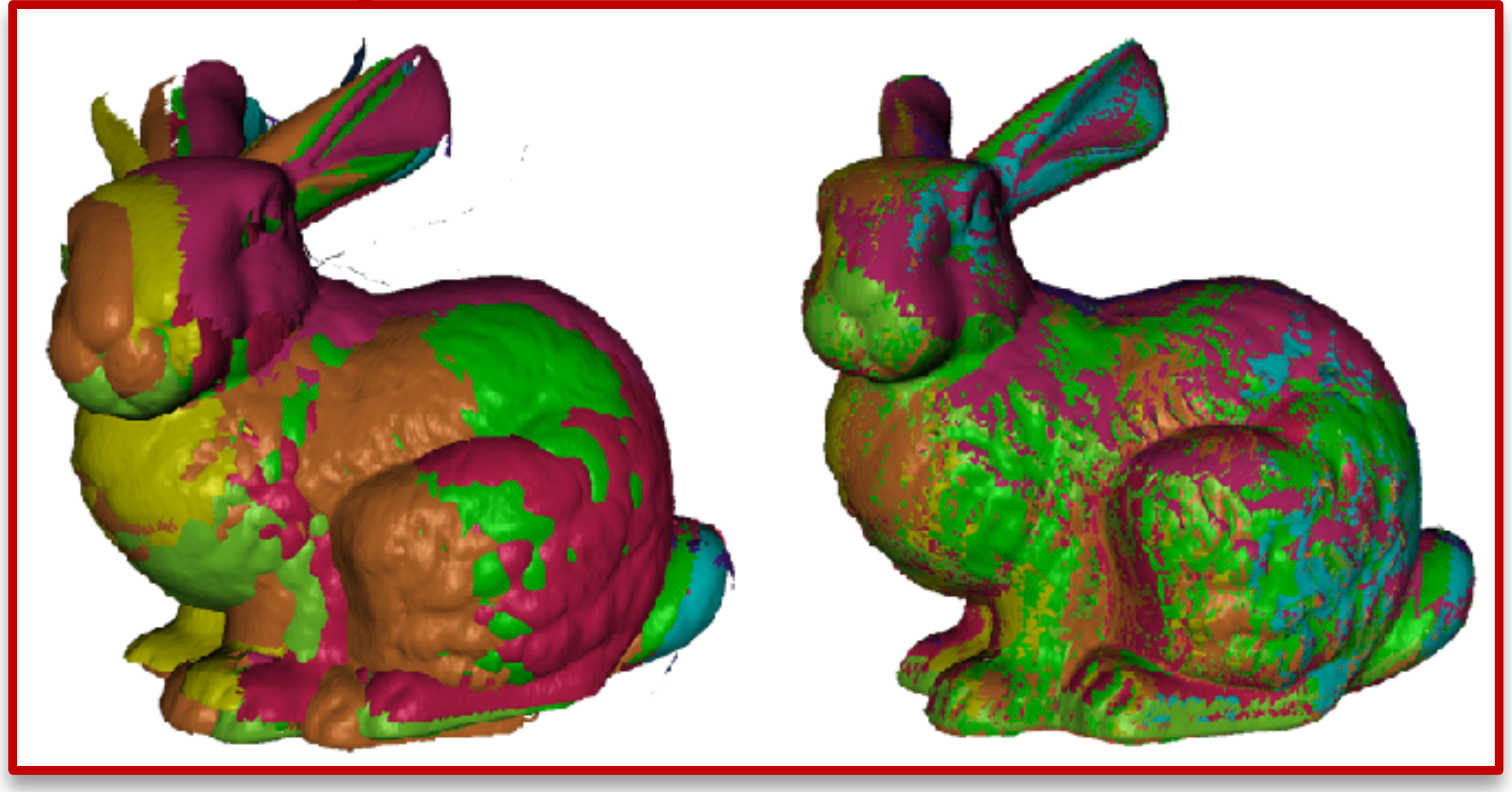
Geometry Acquisition Pipeline

Scanning: results in range images

Registration: bring all range images to one coordinate system

Stitching/ reconstruction: Integration of scans into a single mesh

Postprocess:
- Topological and geometric filtering
- Remeshing
- Compression



Geometry Acquisition Pipeline

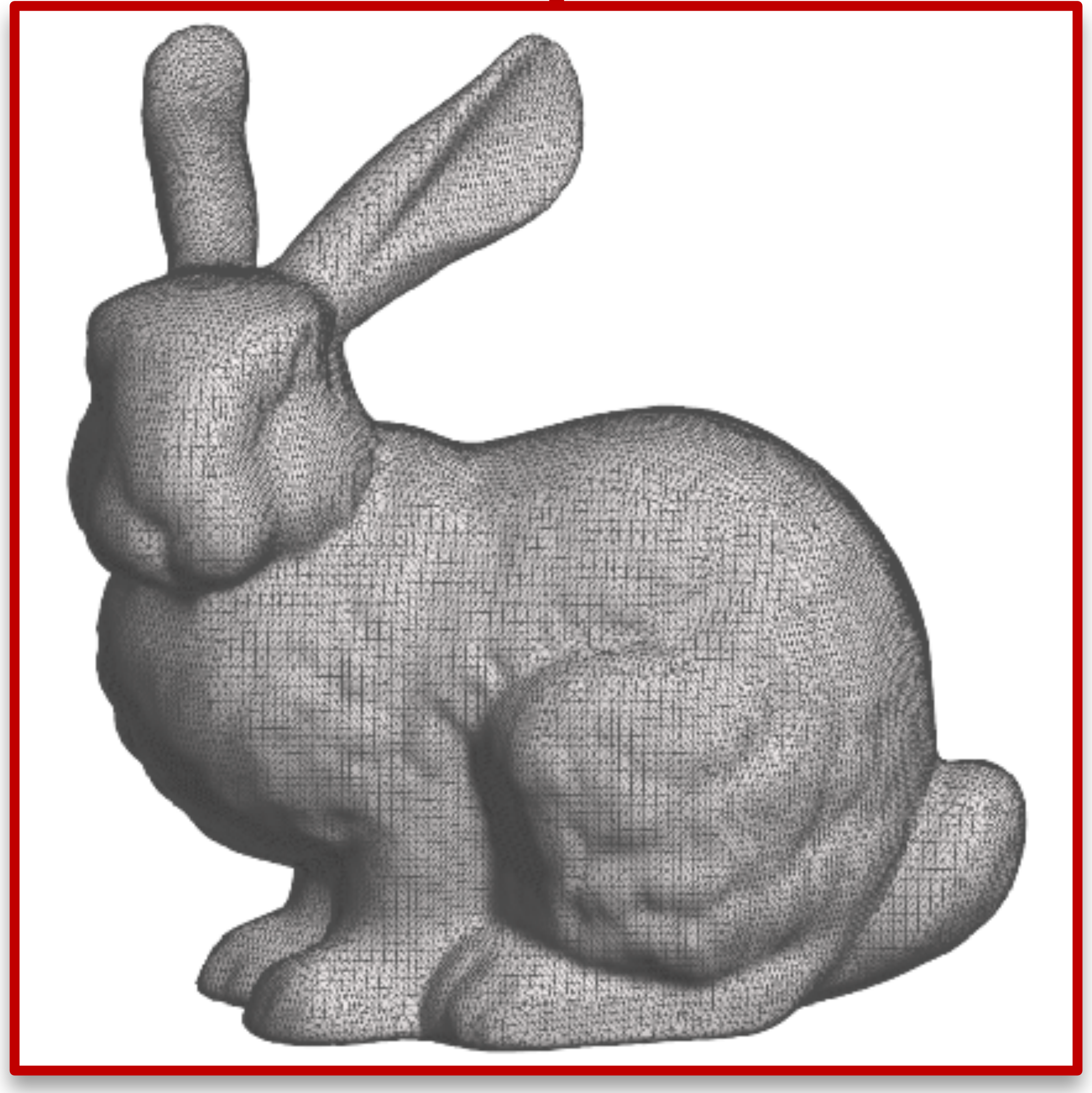
Scanning:
results in range images

⇨

Registration:
bring all range images to one coordinate system

⇨

Stitching/ reconstruction:
Integration of scans into a single mesh

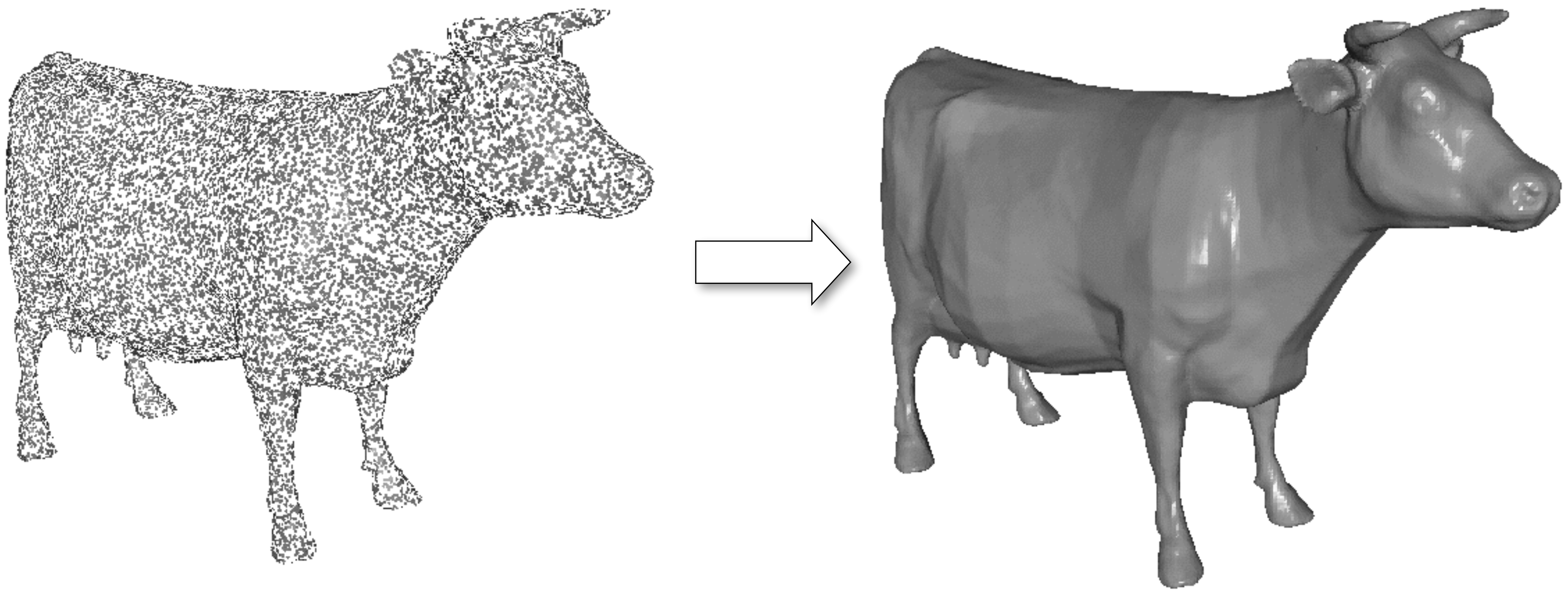


⇨

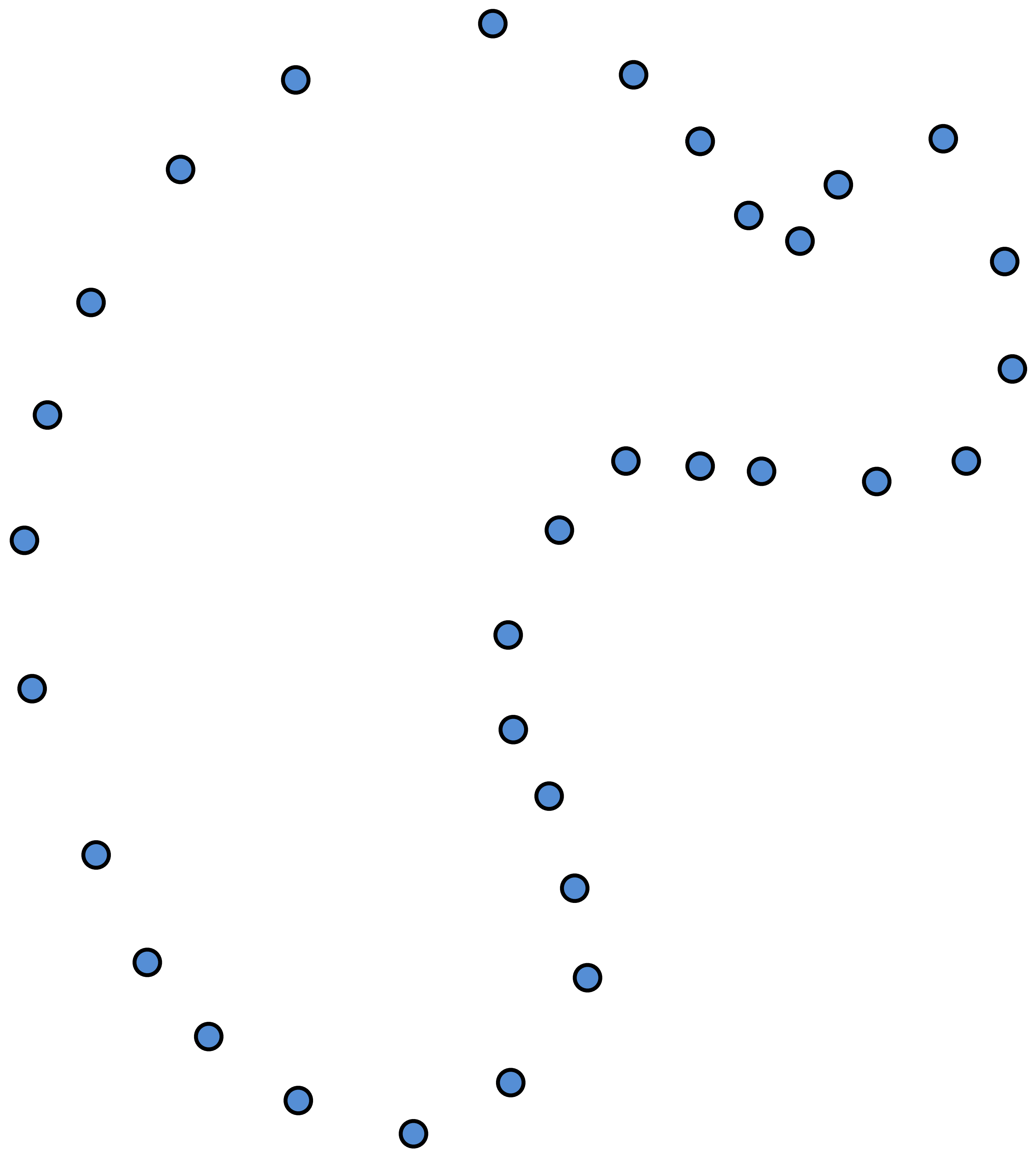
Postprocess:
- Topological and geometric filtering
- Remeshing
- Compression

Surface Reconstruction

- Generate a mesh from a set of surface samples



Implicit Function Approach

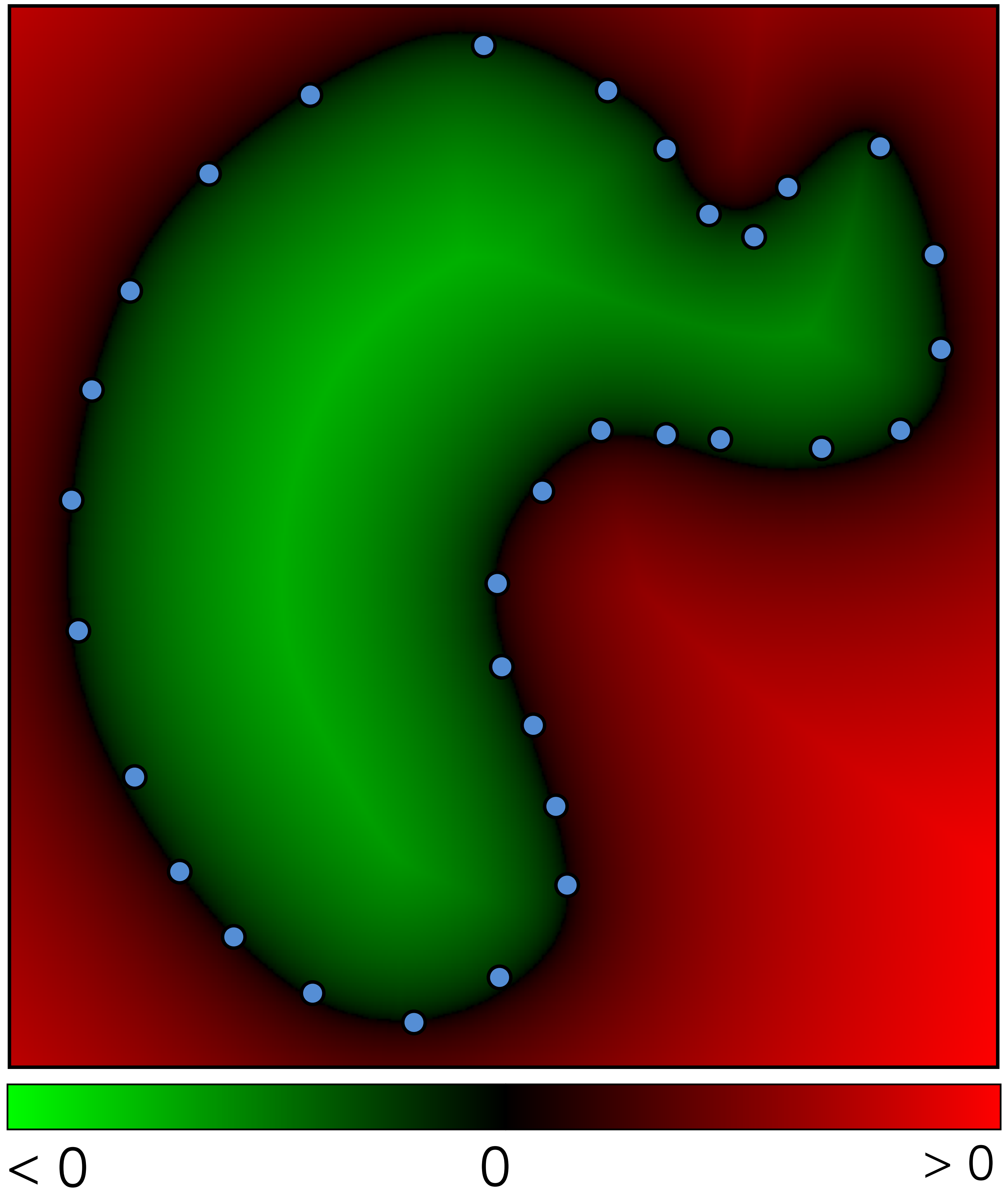


Implicit Function Approach

- Define a function

$$f : \mathbb{R}^3 \rightarrow \mathbb{R}$$

with value > 0 outside the shape and < 0 inside



Implicit Function Approach

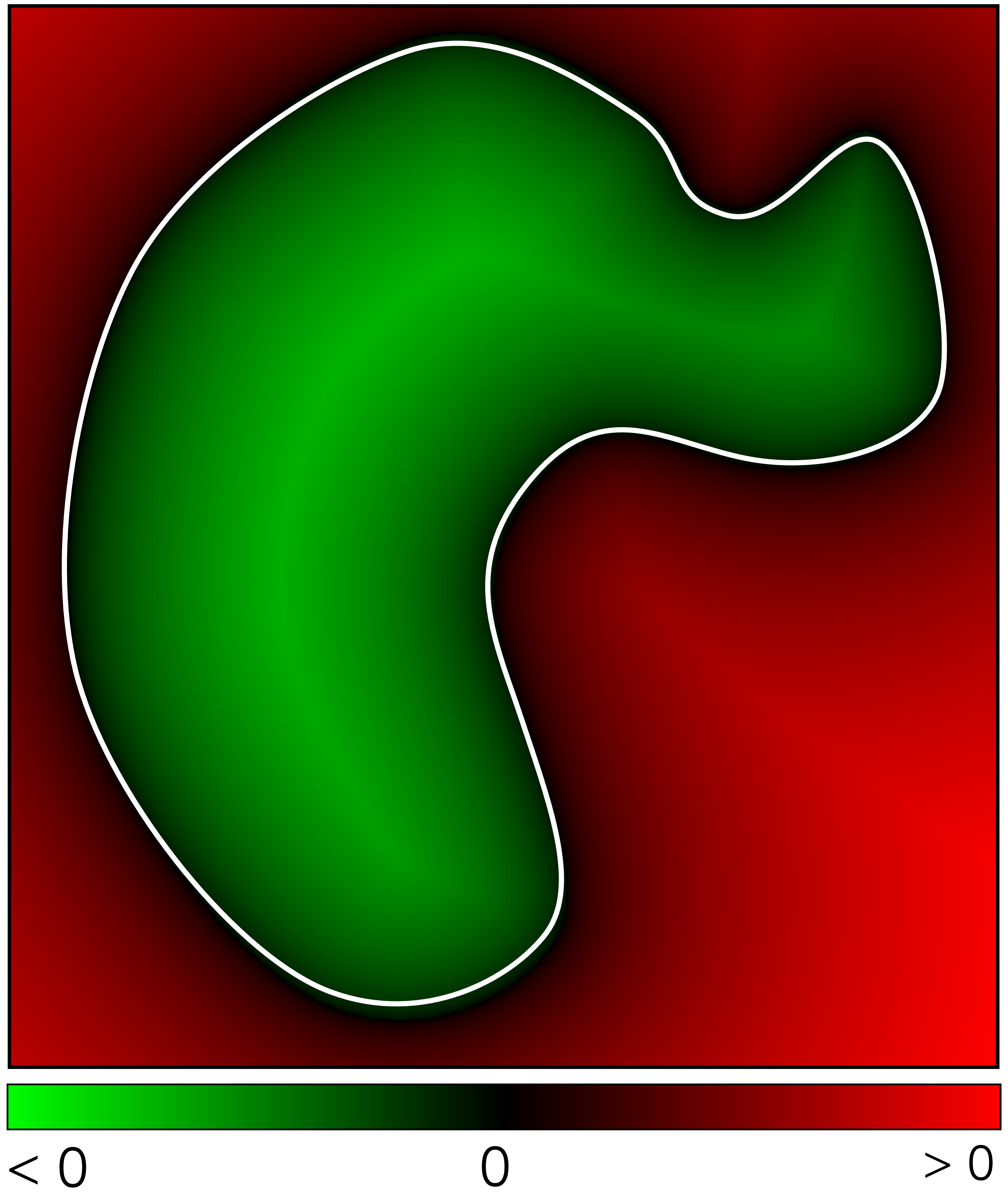
- Define a function

$$f : \mathbb{R}^3 \rightarrow \mathbb{R}$$

  with value > 0 outside the shape and < 0 inside

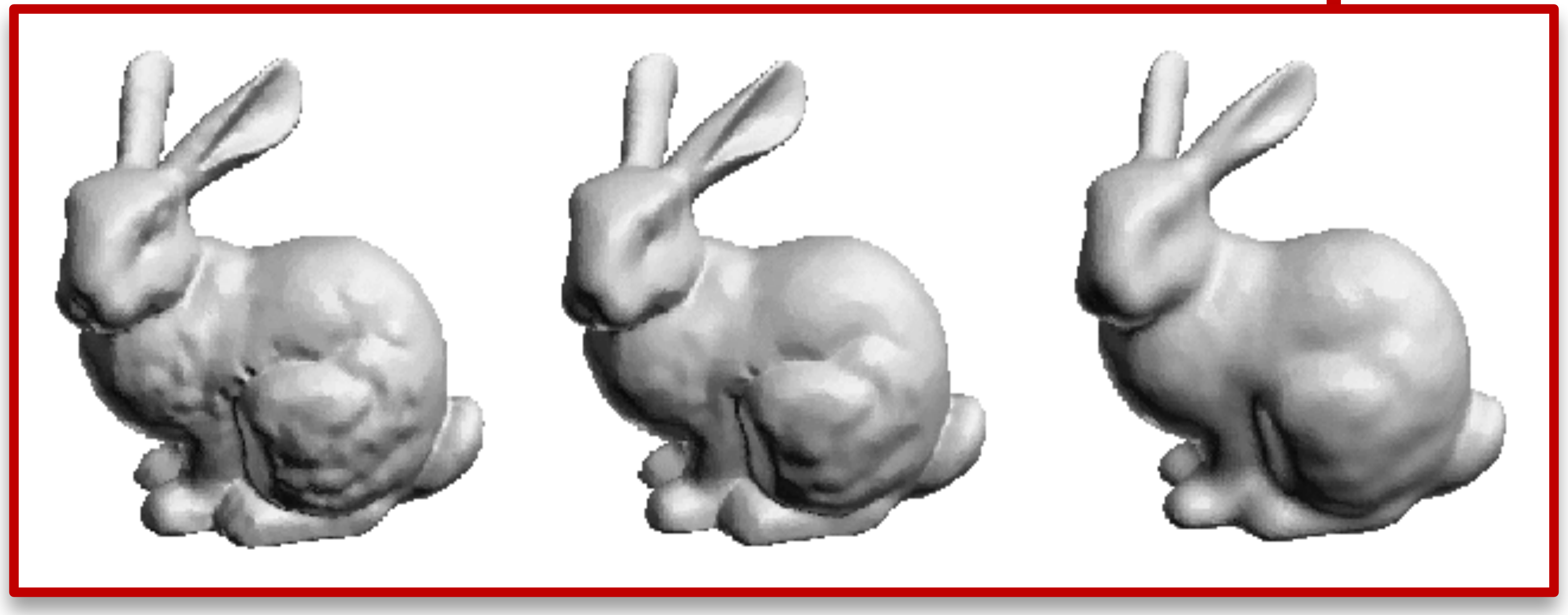
- Extract the zero-set

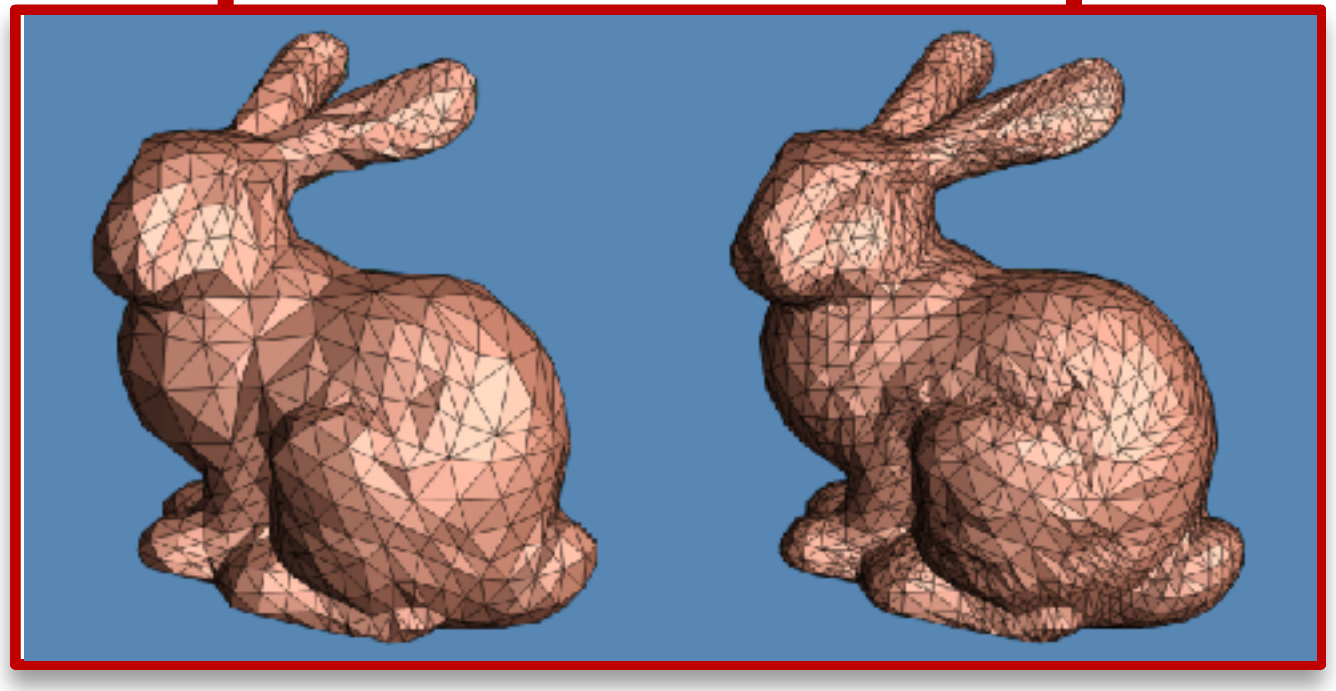
$$\{\mathbf{x} : f(\mathbf{x}) = 0\}$$



Geometry Acquisition Pipeline

Scanning: results in range images ⇨ **Registration:** bring all range images to one coordinate system ⇨ **Stitching/ reconstruction:** Integration of scans into a single mesh ⇨ **Postprocess:**
- Topological and geometric filtering
- Remeshing
- Compression





Scanning

Touch Probes

Touch Probes

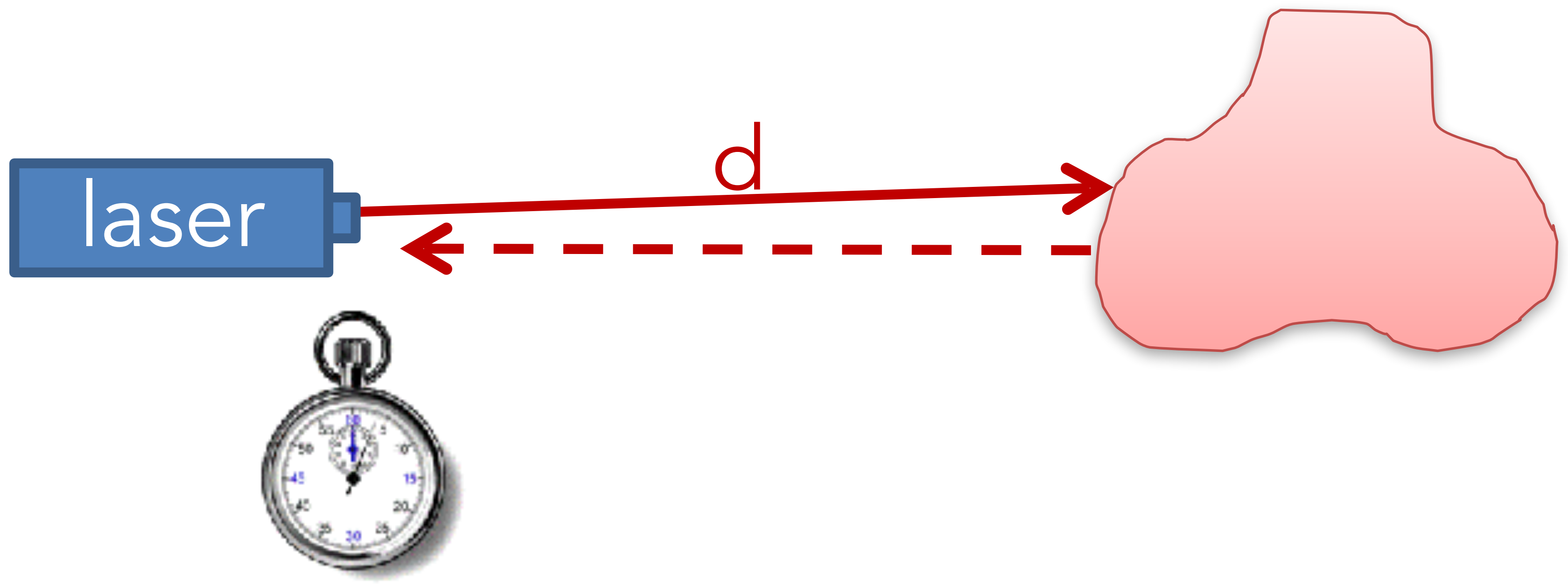
- Physical contact with the object
- Manual or computer-guided
- Advantages:
  - Can be very precise
  - Can scan any solid surface
- Disadvantages:
  - Slow, small scale
  - Cannot be used on fragile objects

Optical Scanning

- Infer the geometry from light reflectance
- Advantages:
  - Less invasive than touch
  - Fast, large scale possible
- Disadvantages:
  - Difficulty with transparent and shiny objects

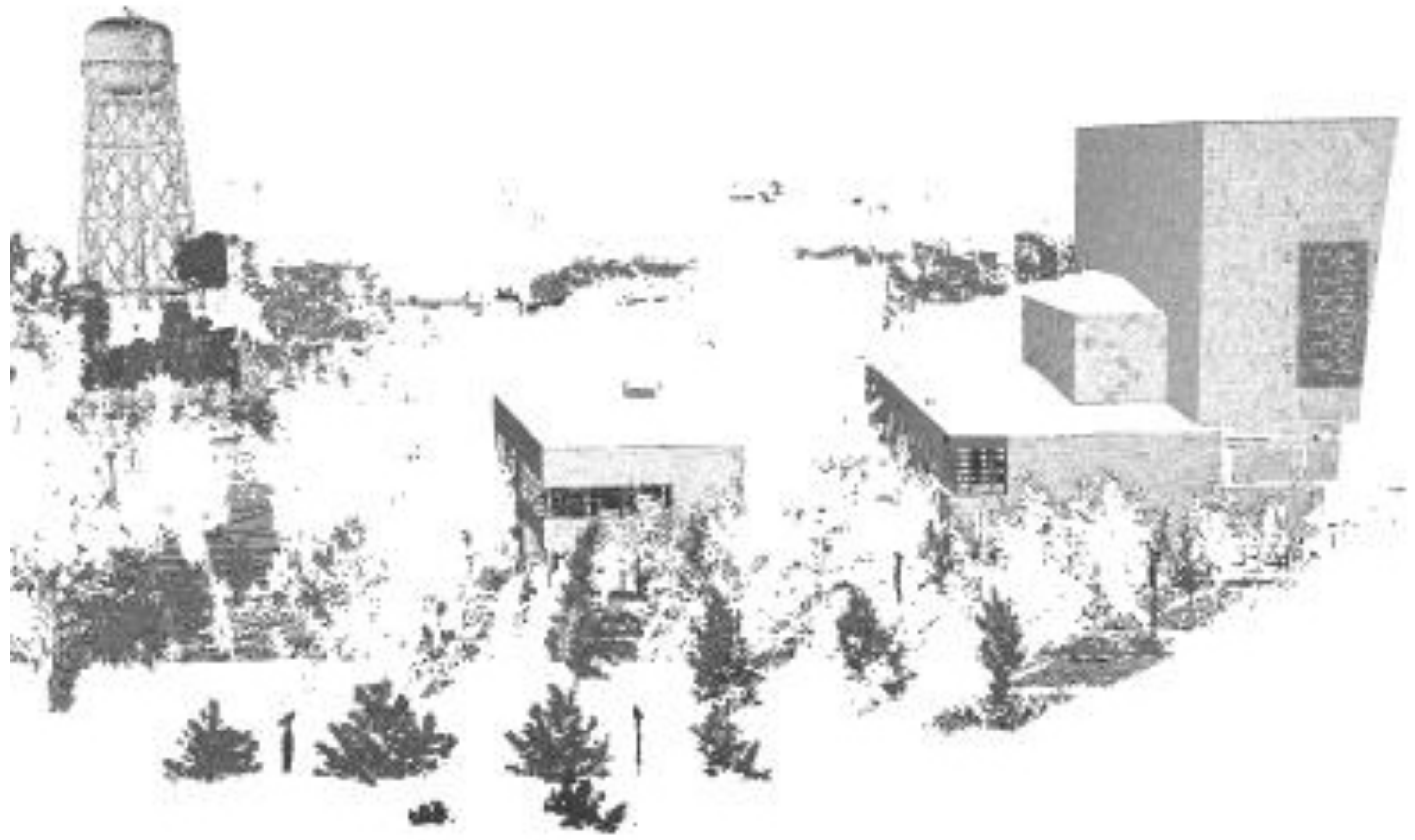
Time of Flight Scanner

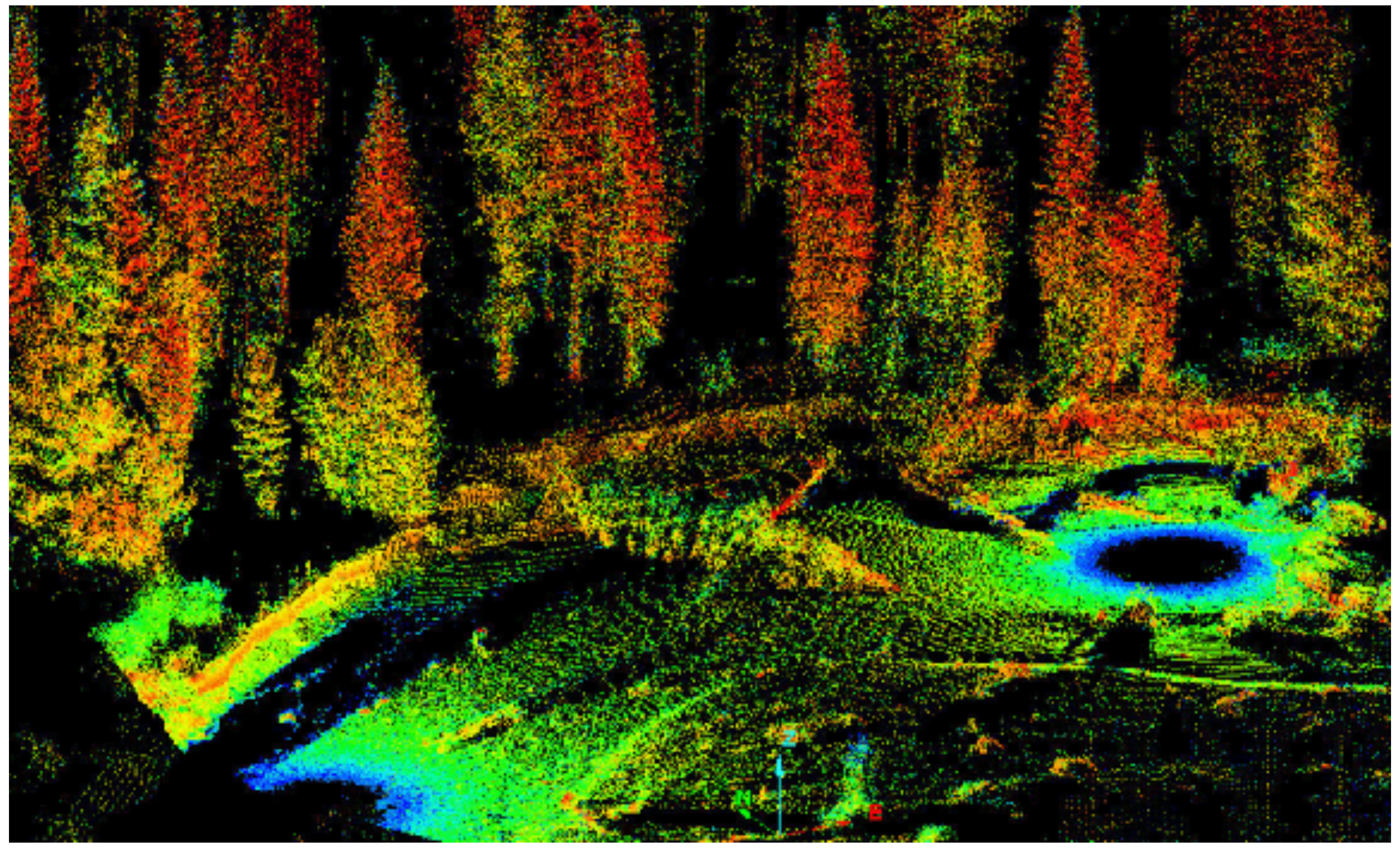
- A type of laser rangefinder (LIDAR)
- Measures the time it takes the laser beam to hit the object and come back



Time of Flight Scanner

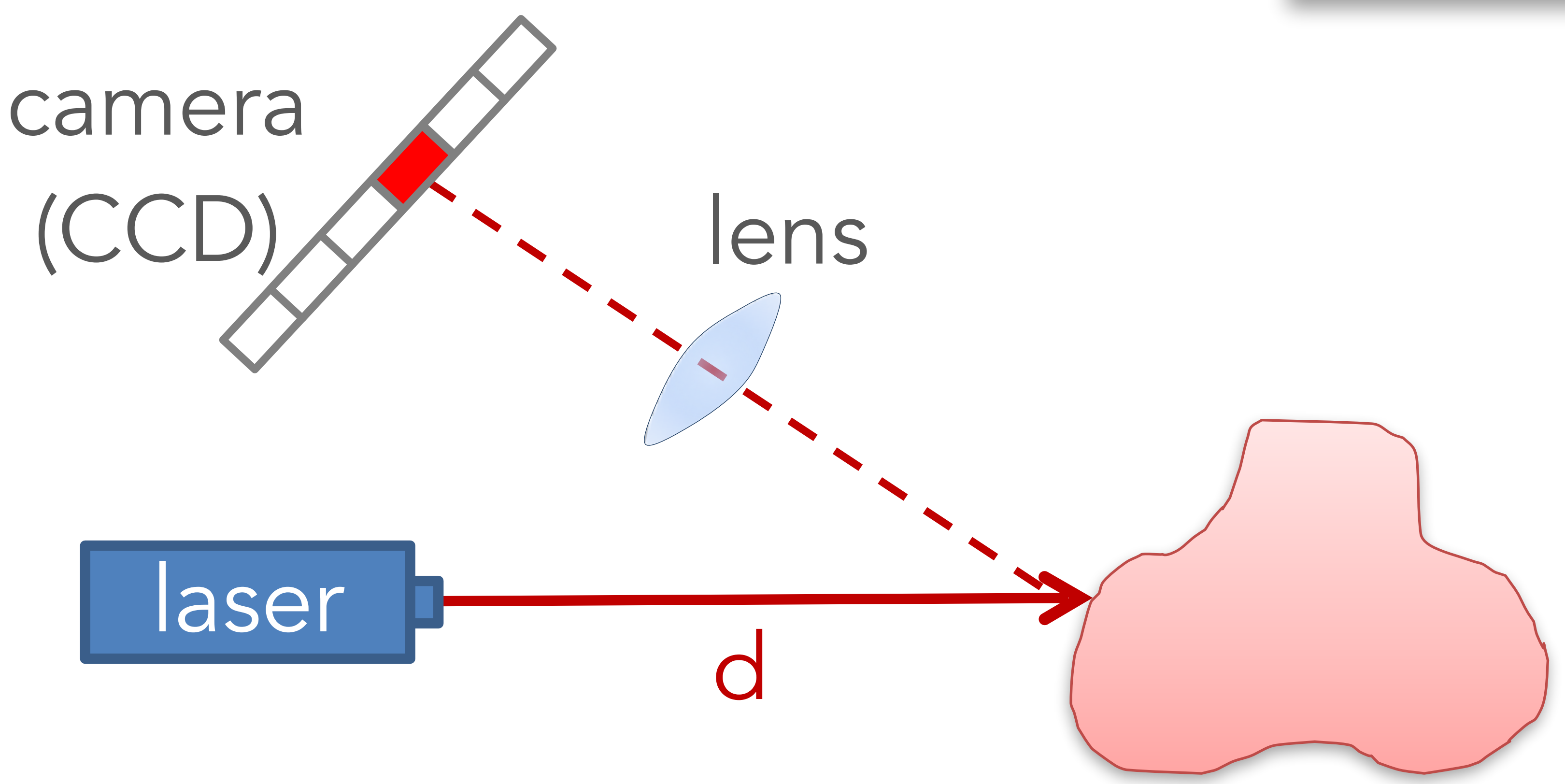
- Accommodates large range – up to several miles (suitable for buildings, rocks)
- Only for static scenes, object motion introduces noise

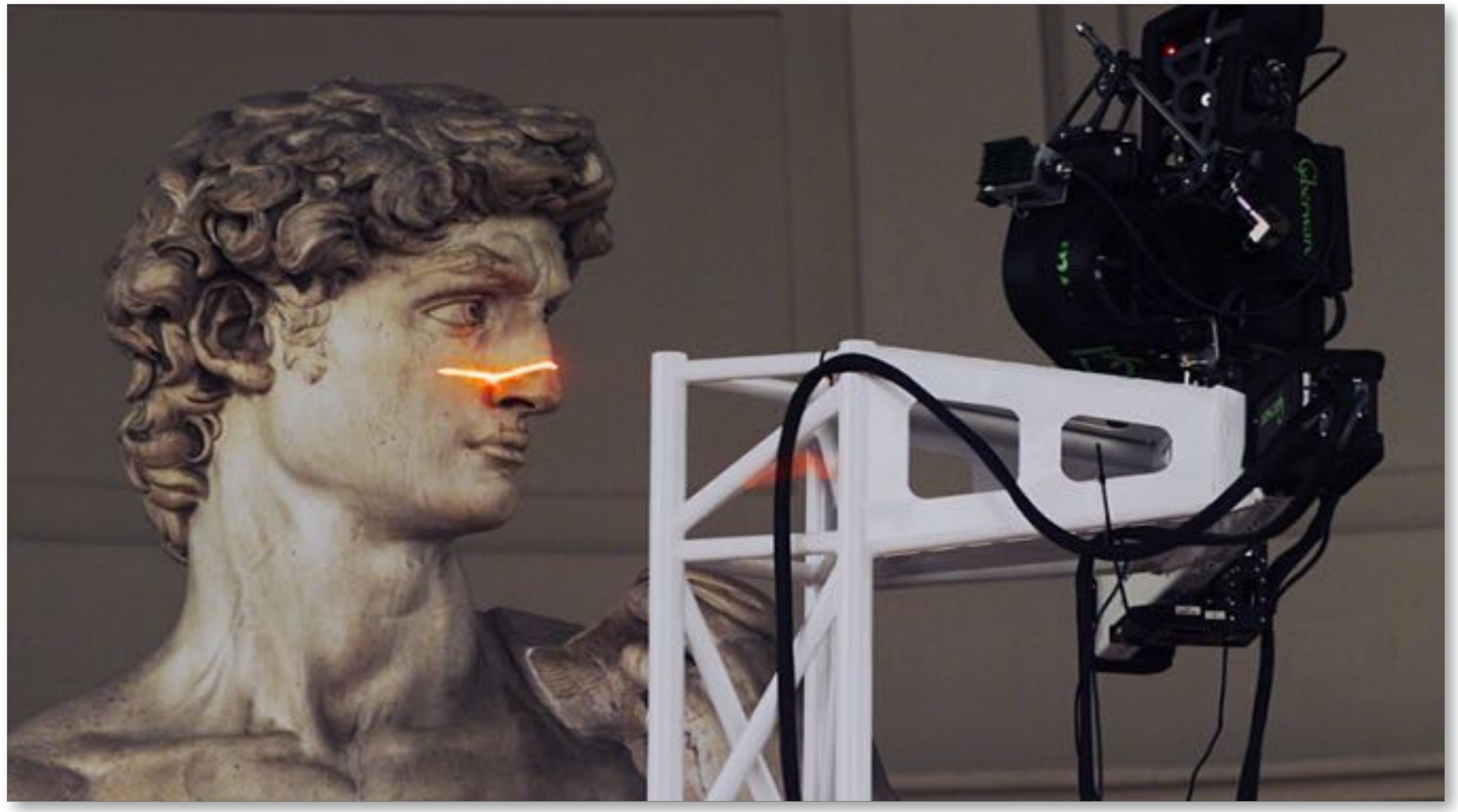




Triangulation Laser

- Laser beam and camera
- Laser dot is photographed
- The location of the dot in the image allows triangulation: we get the distance to the object

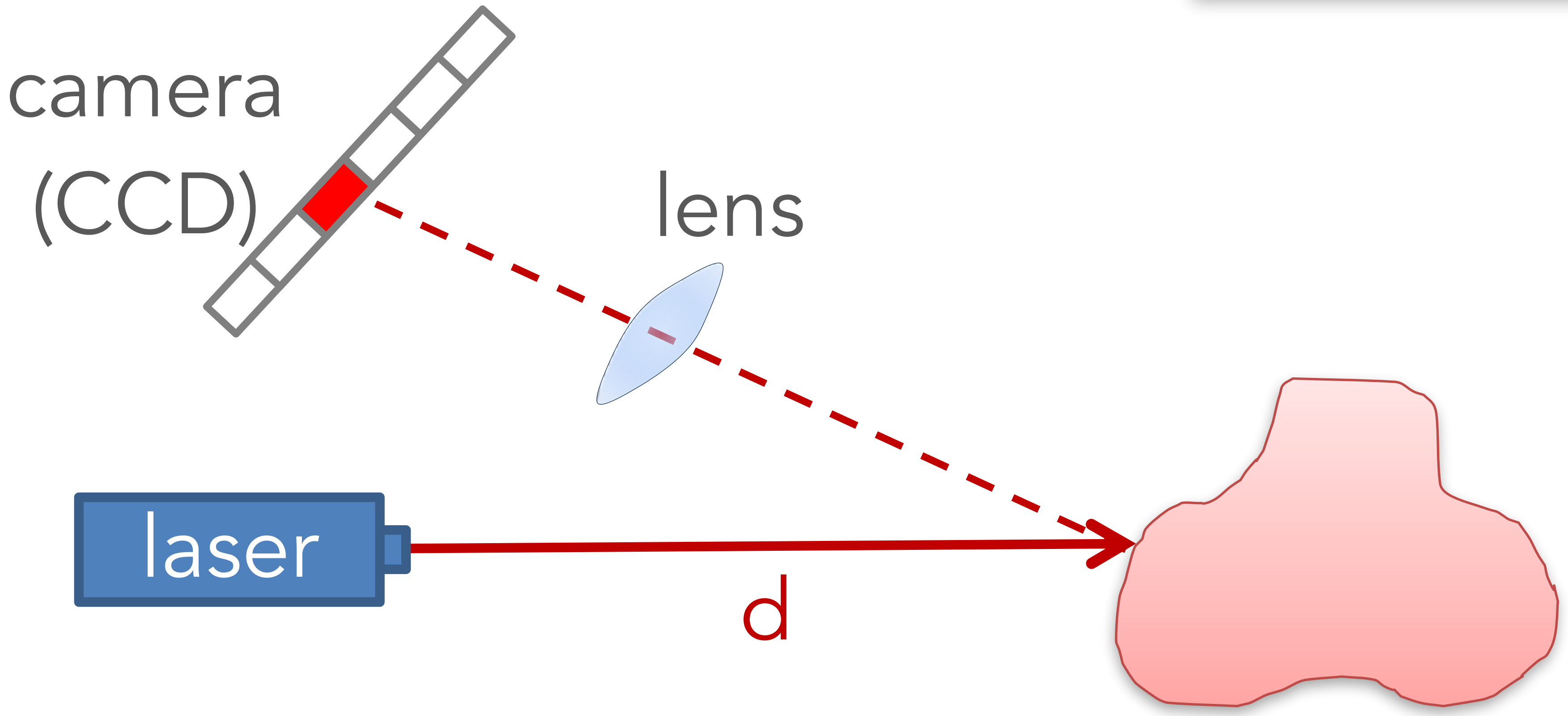


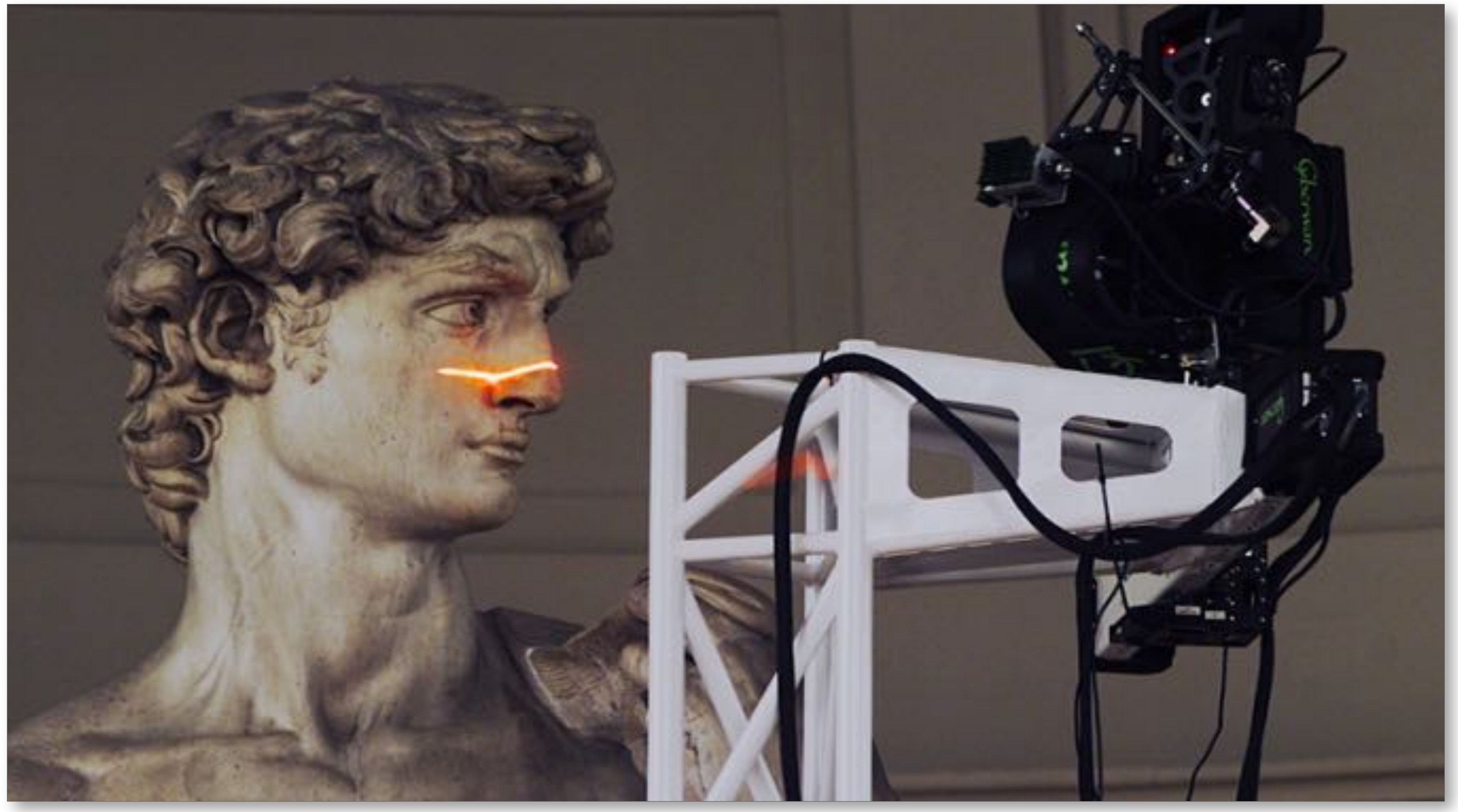


Digital Michelangelo Project

Triangulation Laser

- Laser beam and camera
- Laser dot is photographed
- The location of the dot in the image allows triangulation: we get the distance to the object



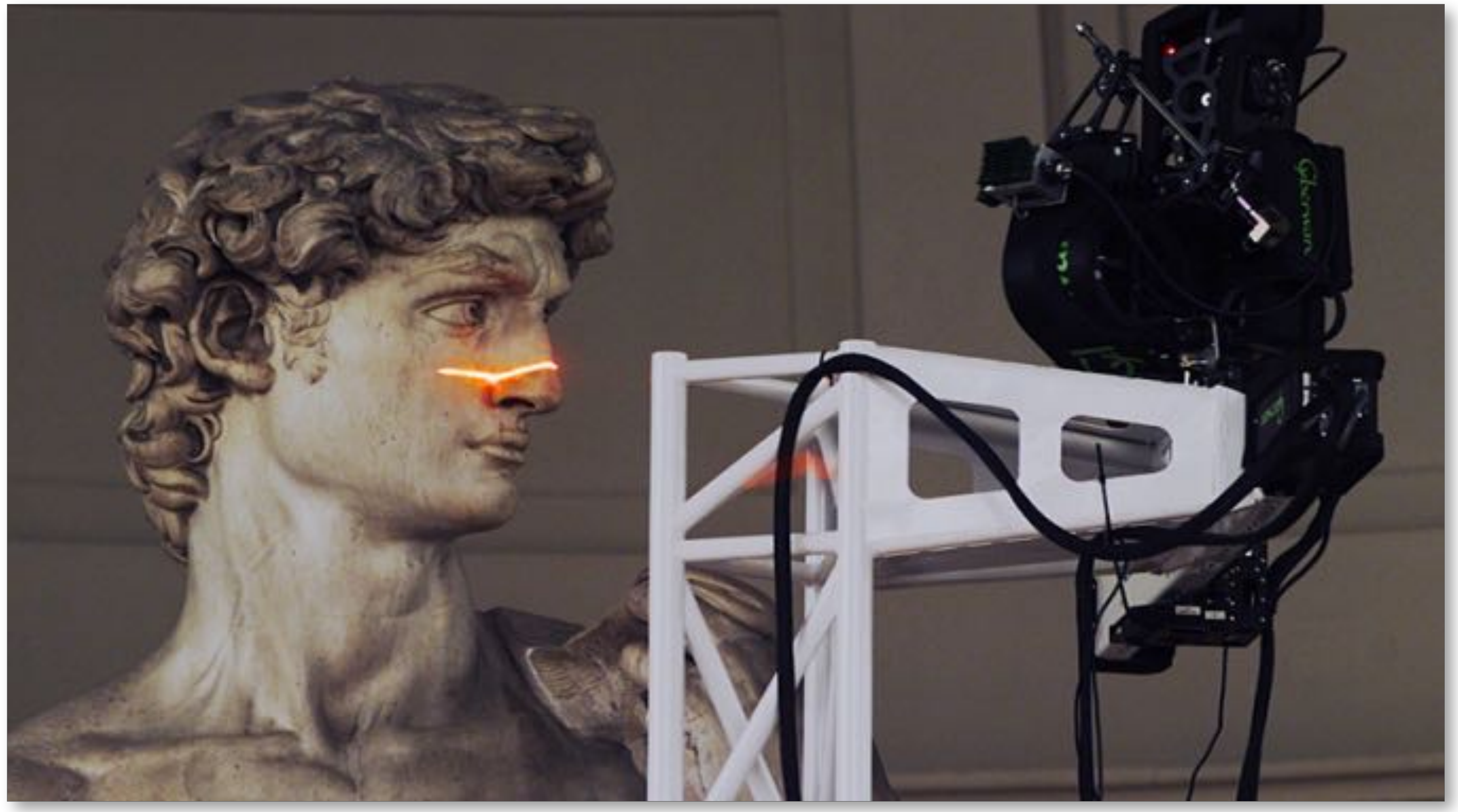


Digital Michelangelo Project

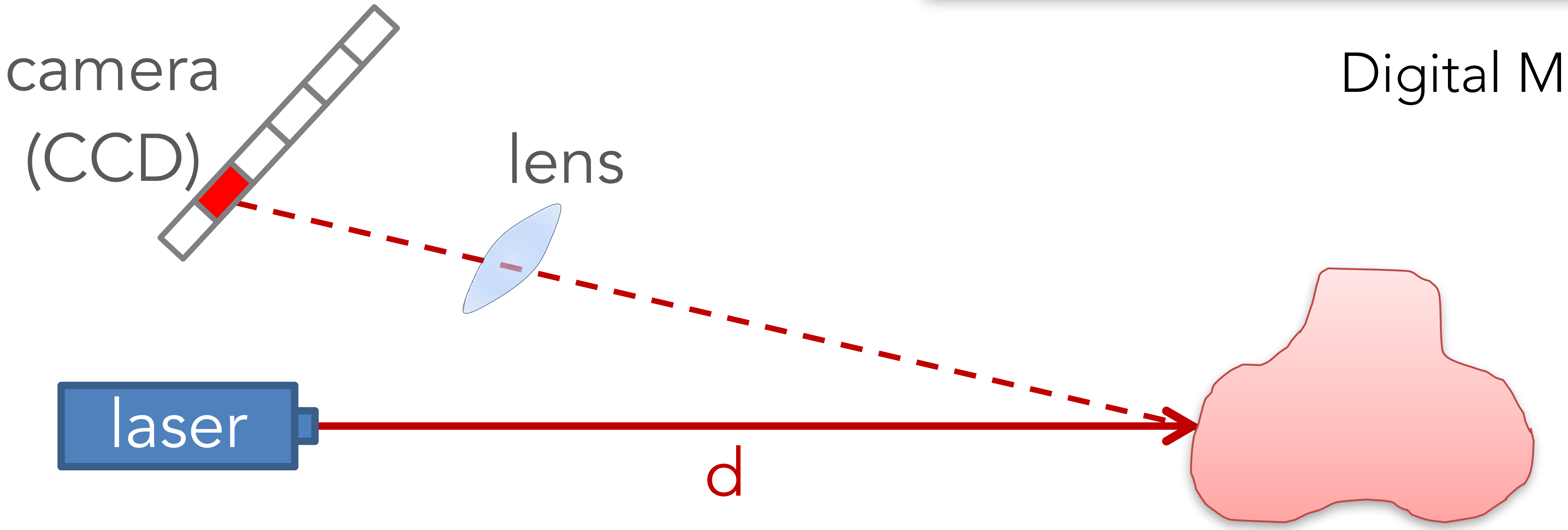
University of Victoria | Computer Science

Triangulation Laser

- Laser beam and camera
- Laser dot is photographed
- The location of the dot in the image allows triangulation: we get the distance to the object

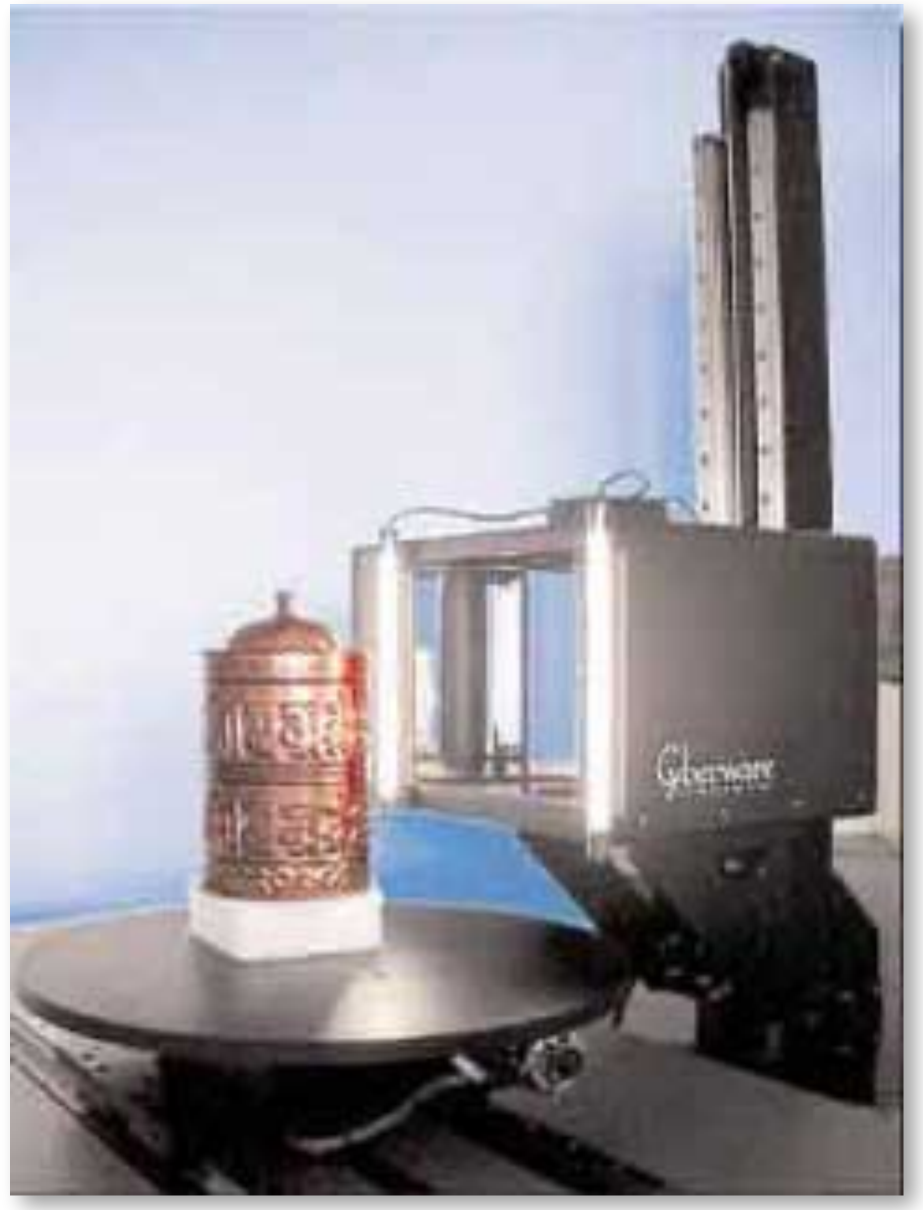


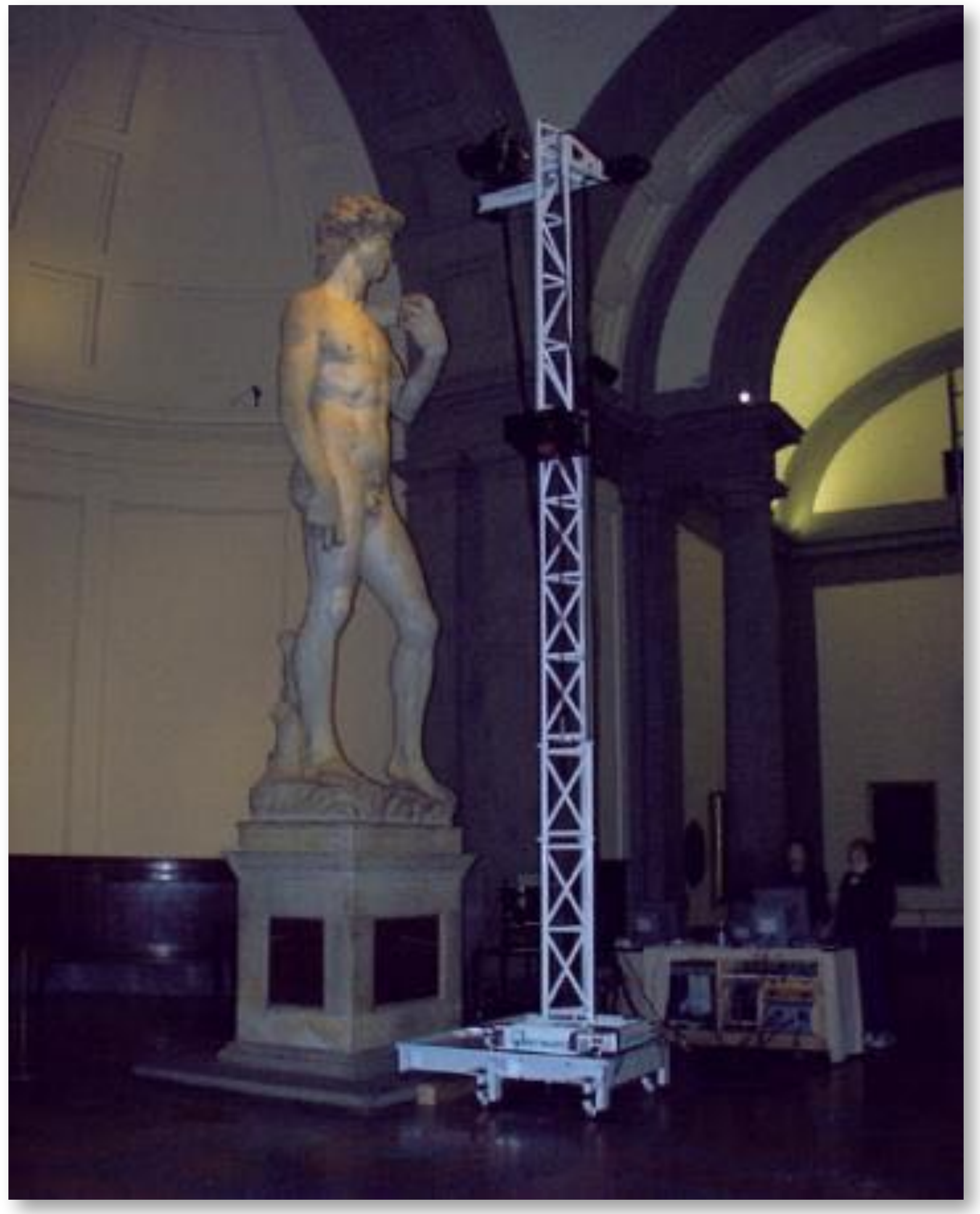
Digital Michelangelo Project



Triangulation Laser

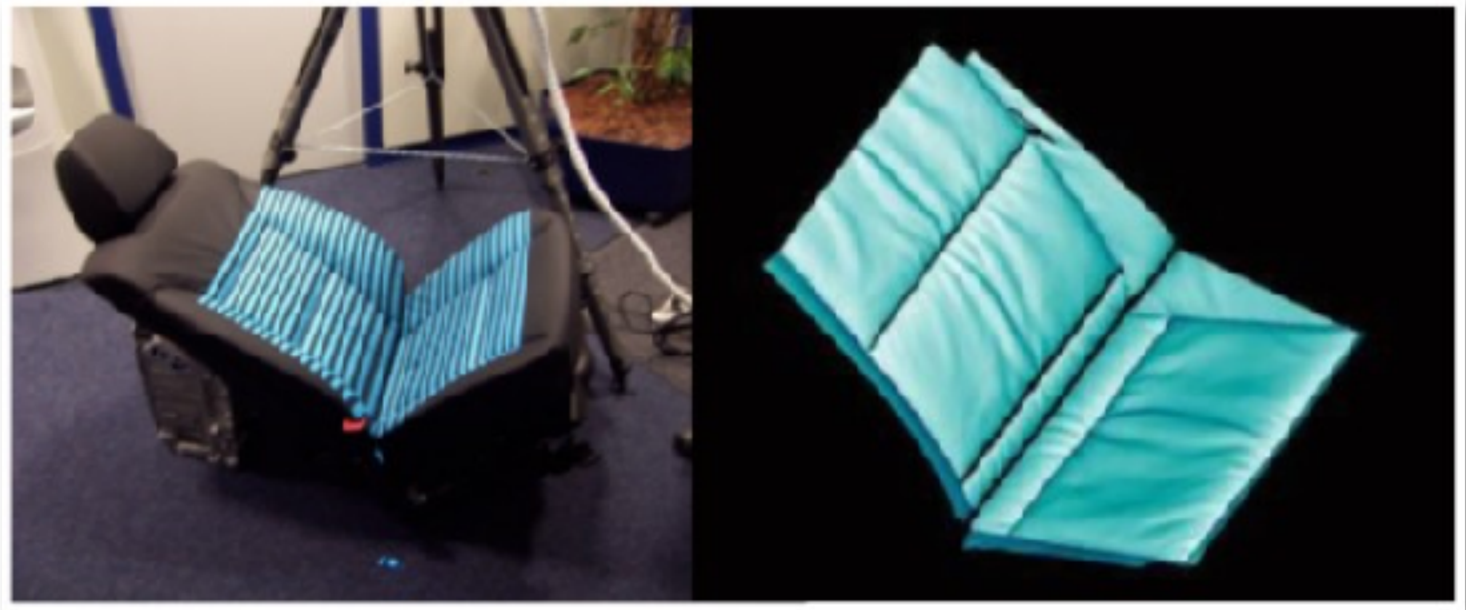
- Very precise (tens of microns)
- Small distances (meters)





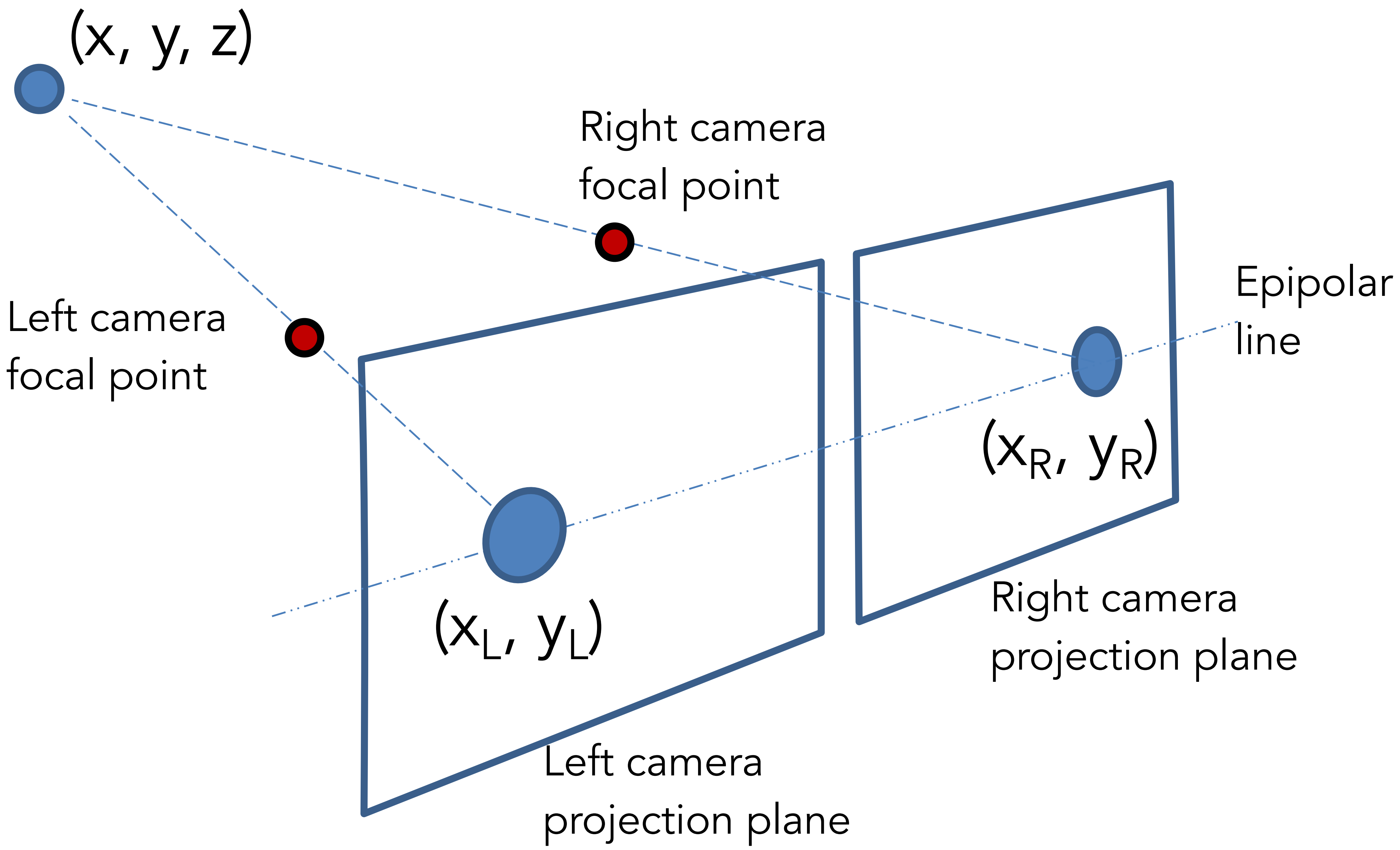
Structured Light

- Pattern of visible or **infrared** light is projected onto the object
- The distortion of the pattern, recorded by the camera, provides geometric information
- Very fast – 2D pattern at once
  - Even in real time, like Kinect 1.0
- Complex distance calculation, prone to noise



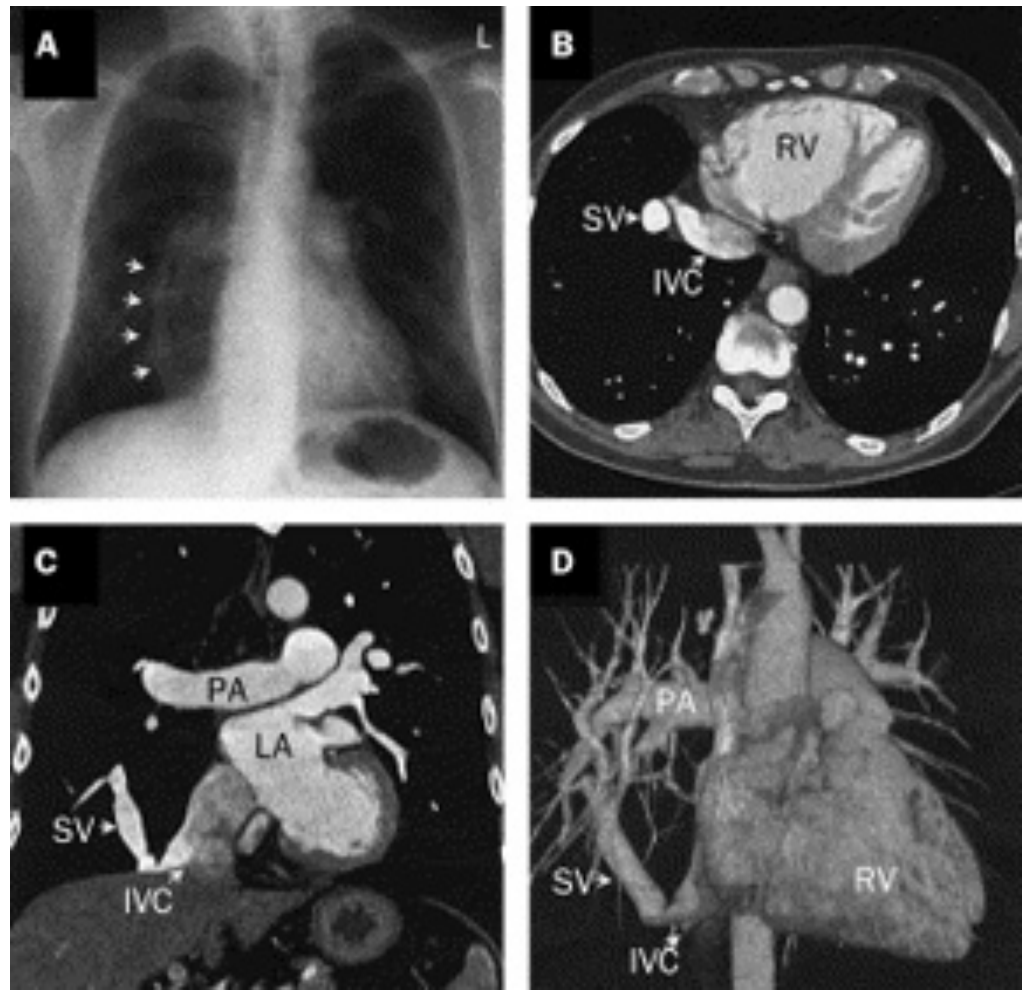
Passive Stereo

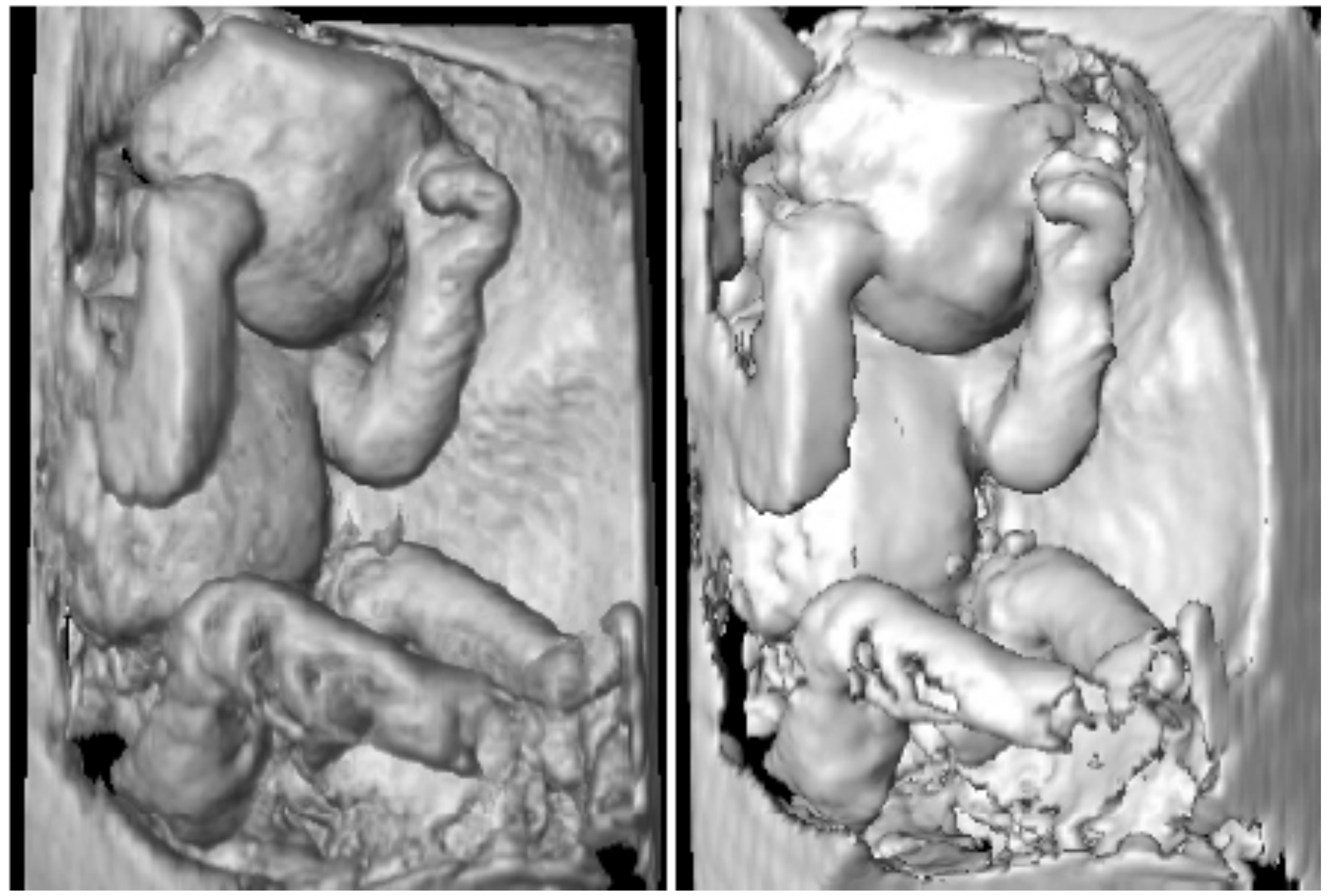
- No need for special lighting/radiation
- Two (or more) cameras
- Feature matching and triangulation

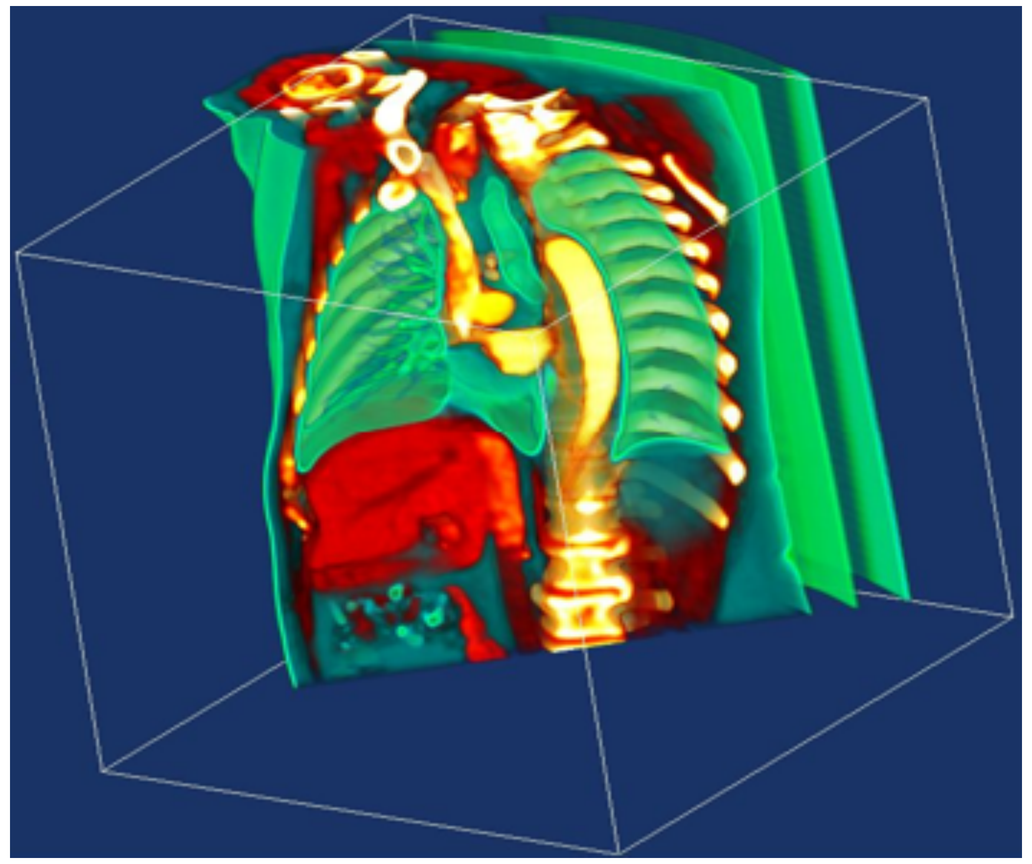


Medical Imaging

- Ultrasound, CT, MRI
- Discrete volume of density data
- Requires segmenting the desired object (contouring)





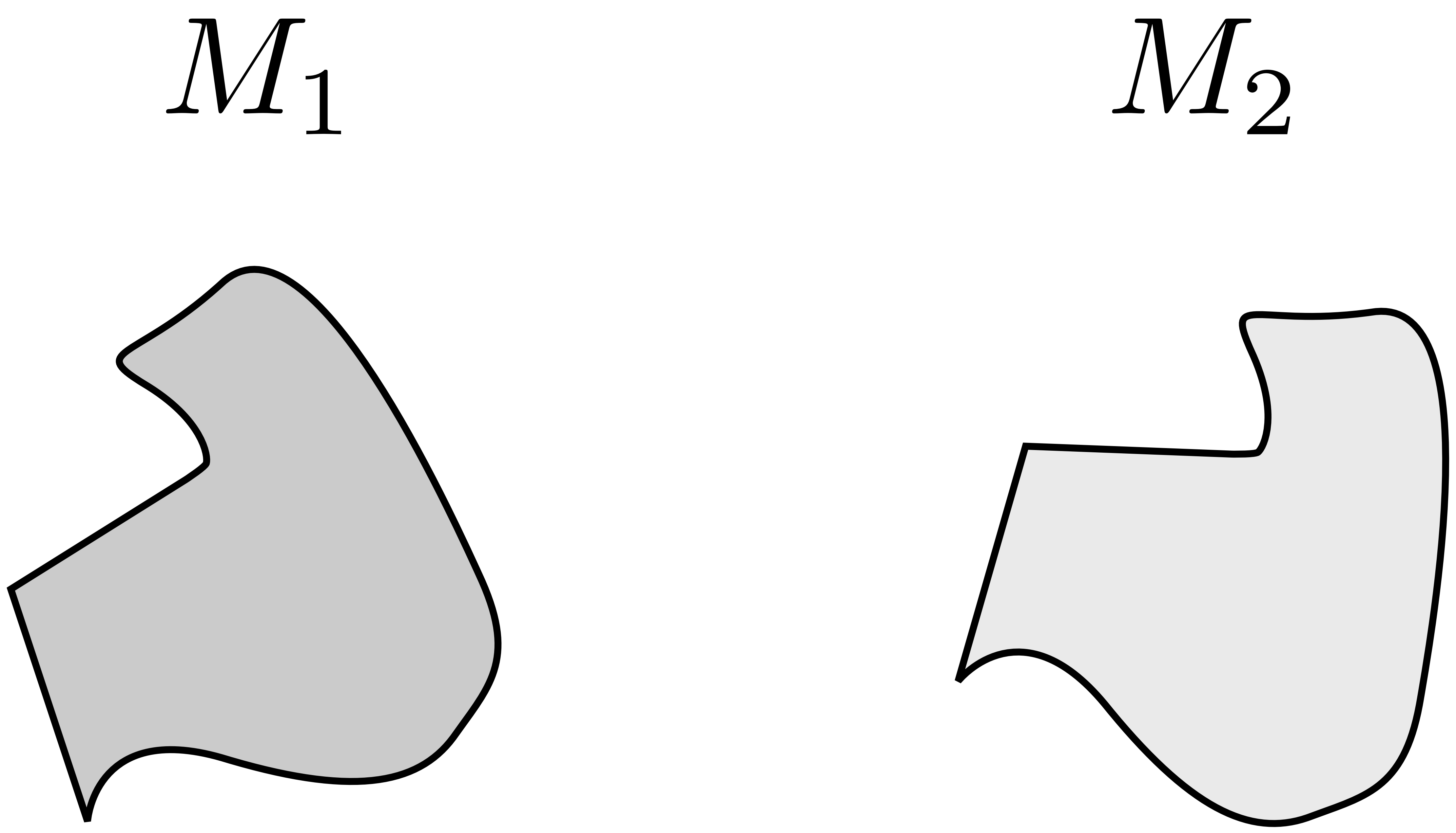


Registration

Acknowledgement: Niloy Mitra
http://resources.mpi-inf.mpg.de/deformableShapeMatching/EG2012_Tutorial/

University of Victoria | Computer Science

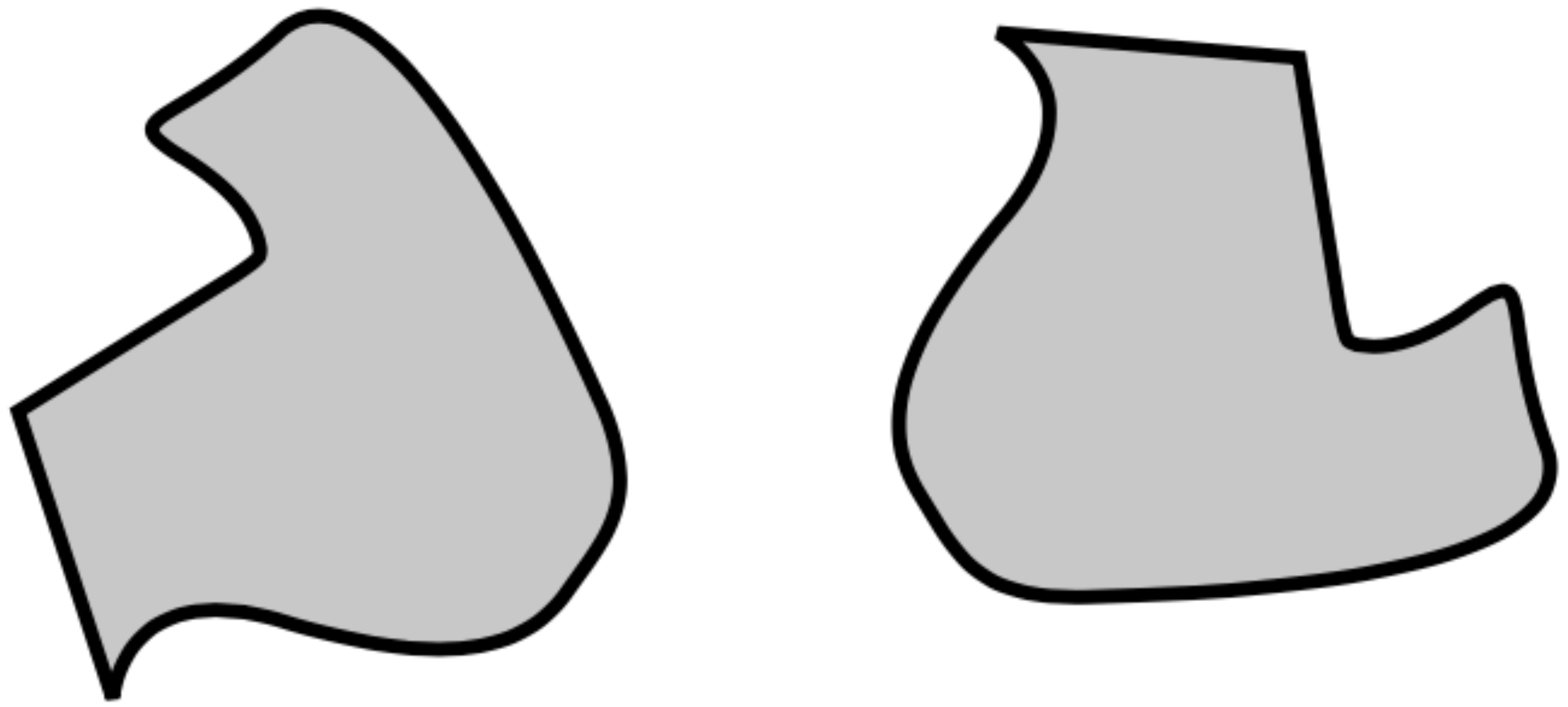
Problem Statement



$$M_1 \approx T(M_2)$$

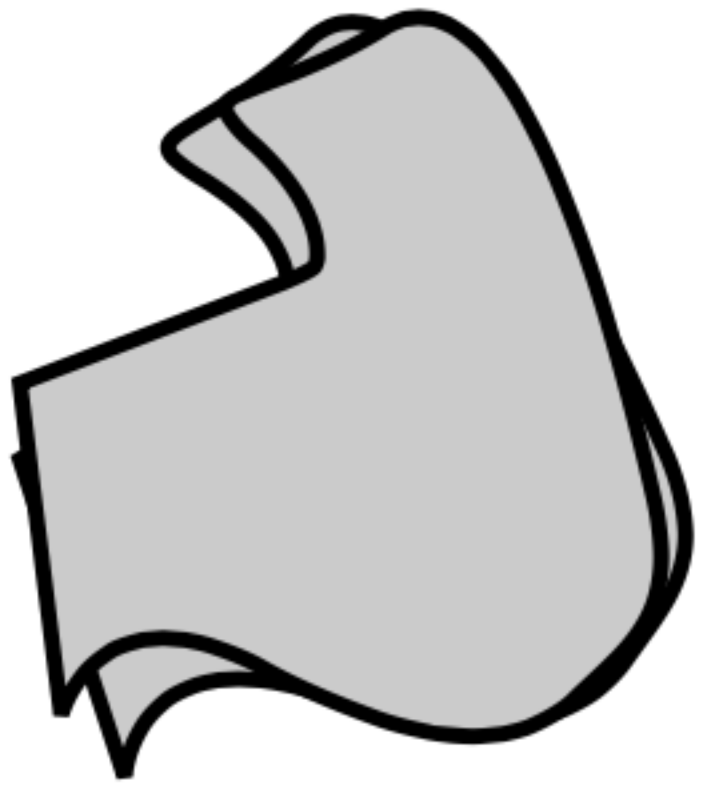
T: Translation + Rotation

Local vs Global



Global Registration

Arbitrary Transformation



Local Registration

"Small" Transformation

$$\text{Given } M_1, \ldots, M_n, \text{ find } T_2, \ldots, T_n \text{ such that}$$

$$M_1 \approx T_2(M_2) \cdots \approx T_n(M_n)$$

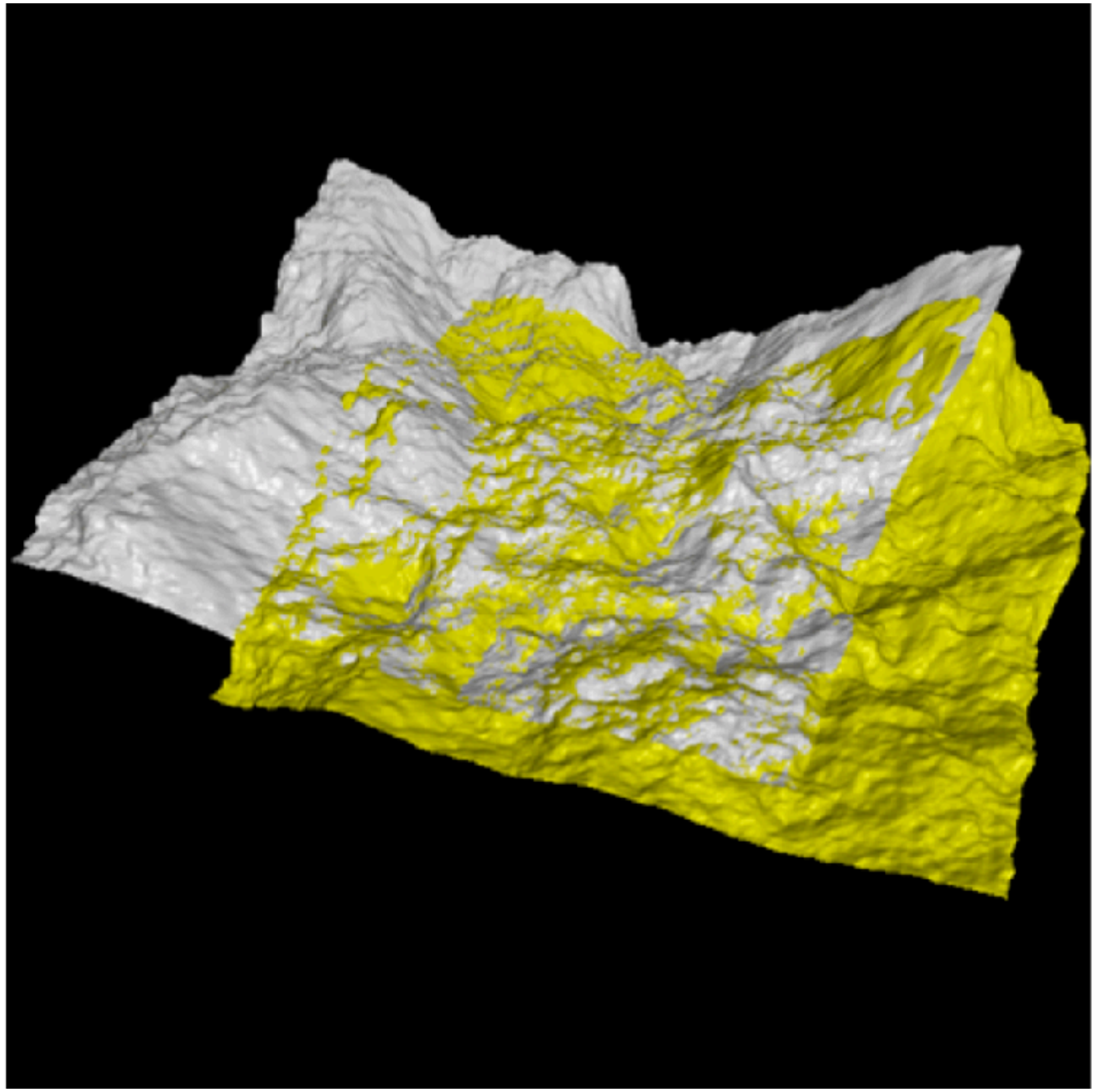
Correspondences

- How many points are needed to define a unique rigid transformation?

- The first problem is finding corresponding pairs!

$$\mathbf{p}_1 \to \mathbf{q}_1$$
$$\mathbf{p}_2 \to \mathbf{q}_2$$
$$\mathbf{p}_3 \to \mathbf{q}_3$$

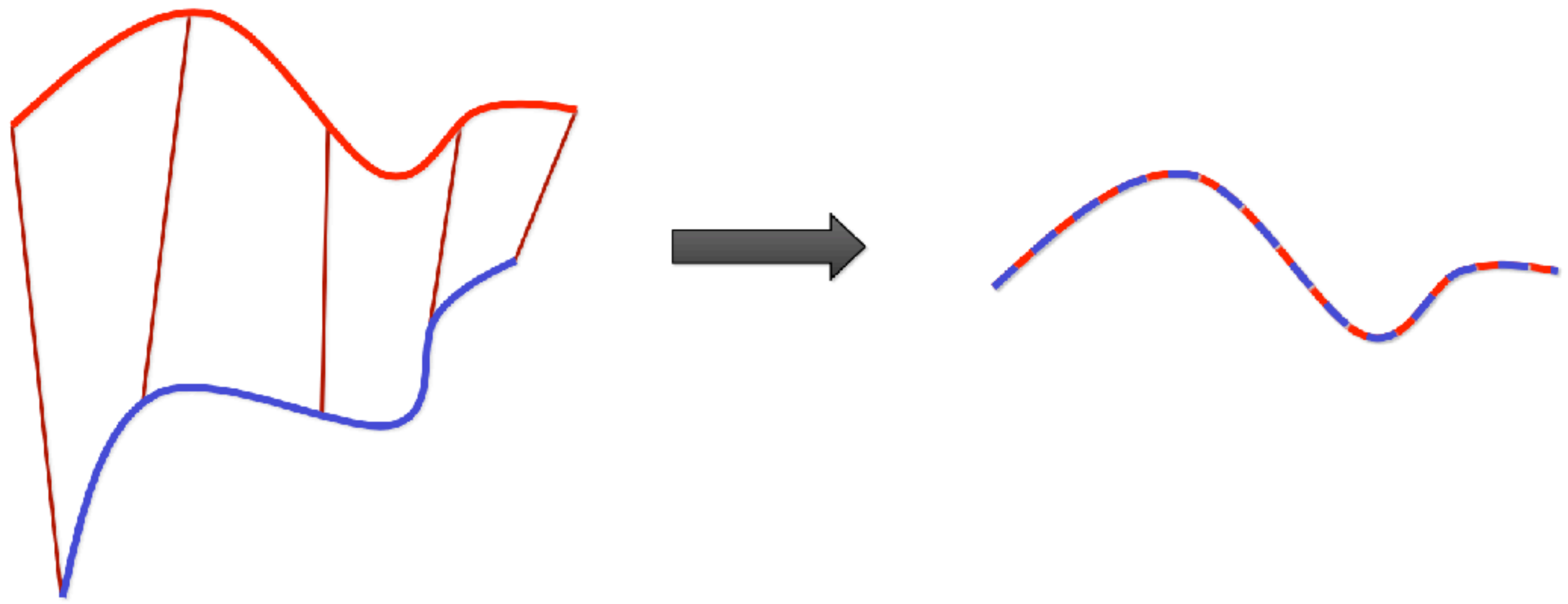
$$R\mathbf{p}_i + t \approx \mathbf{q}_i$$



ICP: Iterative Closest Point

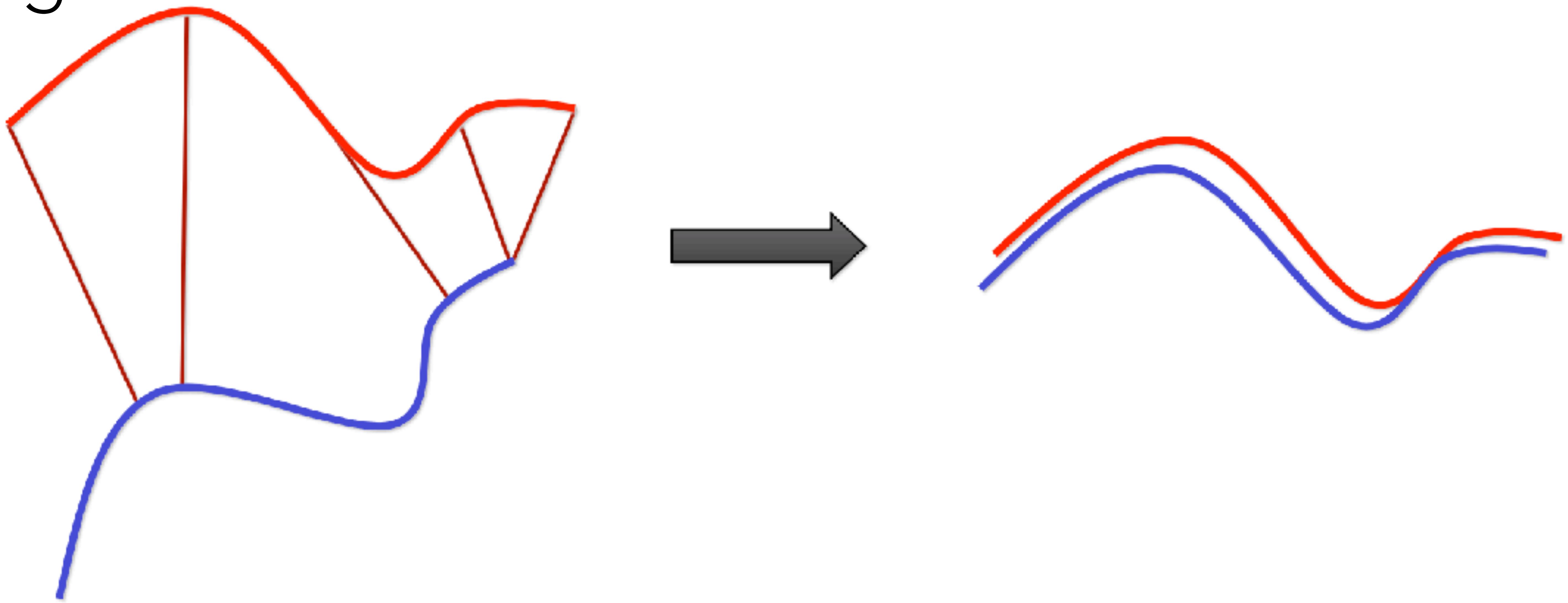
- Idea: Iteratively (1) find correspondences and (2) use them to find a transformation

- Intuition: If you have the right correspondences, then the problem is easy

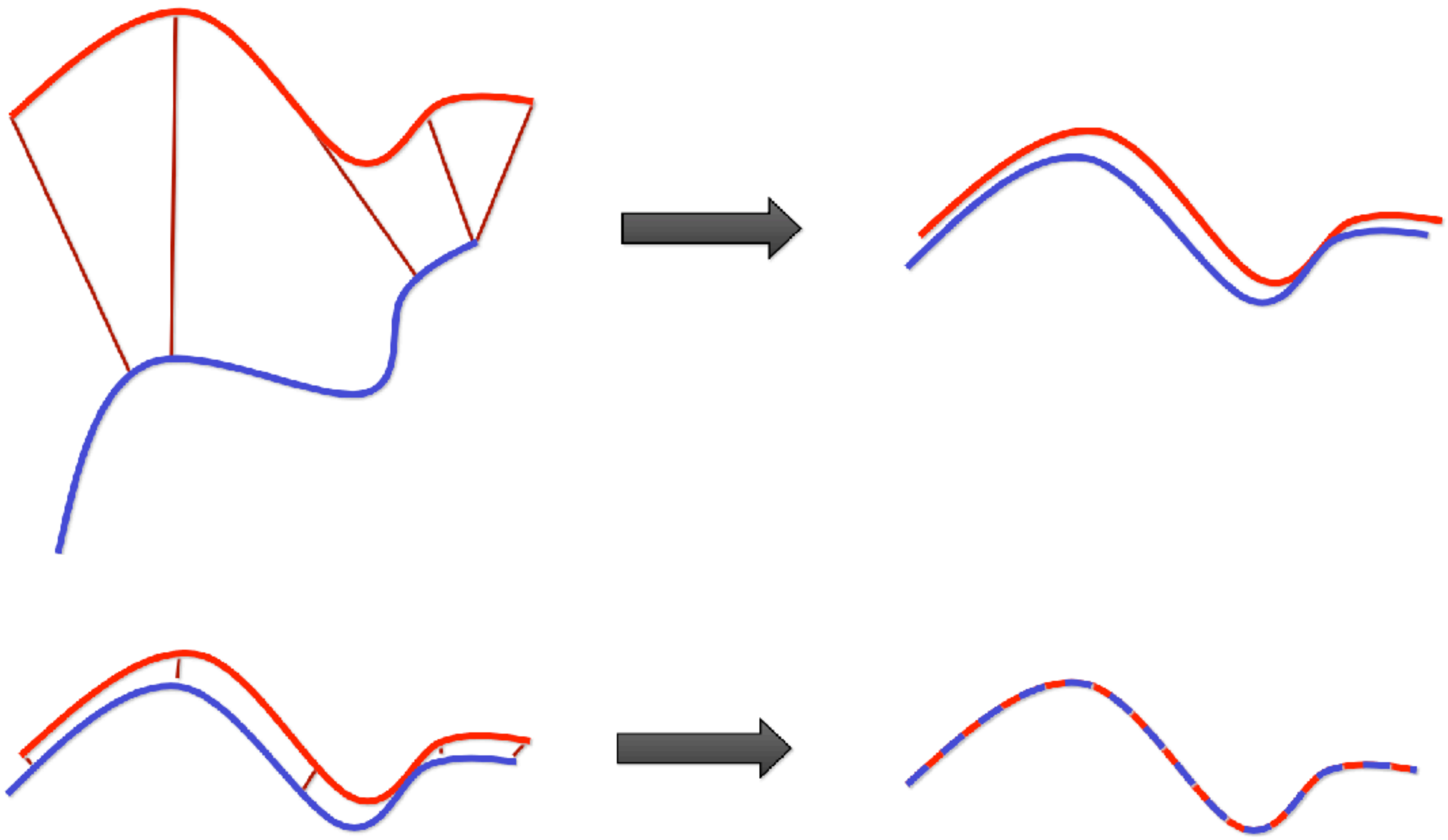


ICP: Iterative Closest Point

- Idea: Iteratively (1) find correspondences and (2) use them to find a transformation
- Intuition: If you don't have the right correspondences, you still can make progress



ICL: Iterative Closest Point



This algorithm converges to the correct solution only if the starting scans are "close enough"

Basic Algorithm

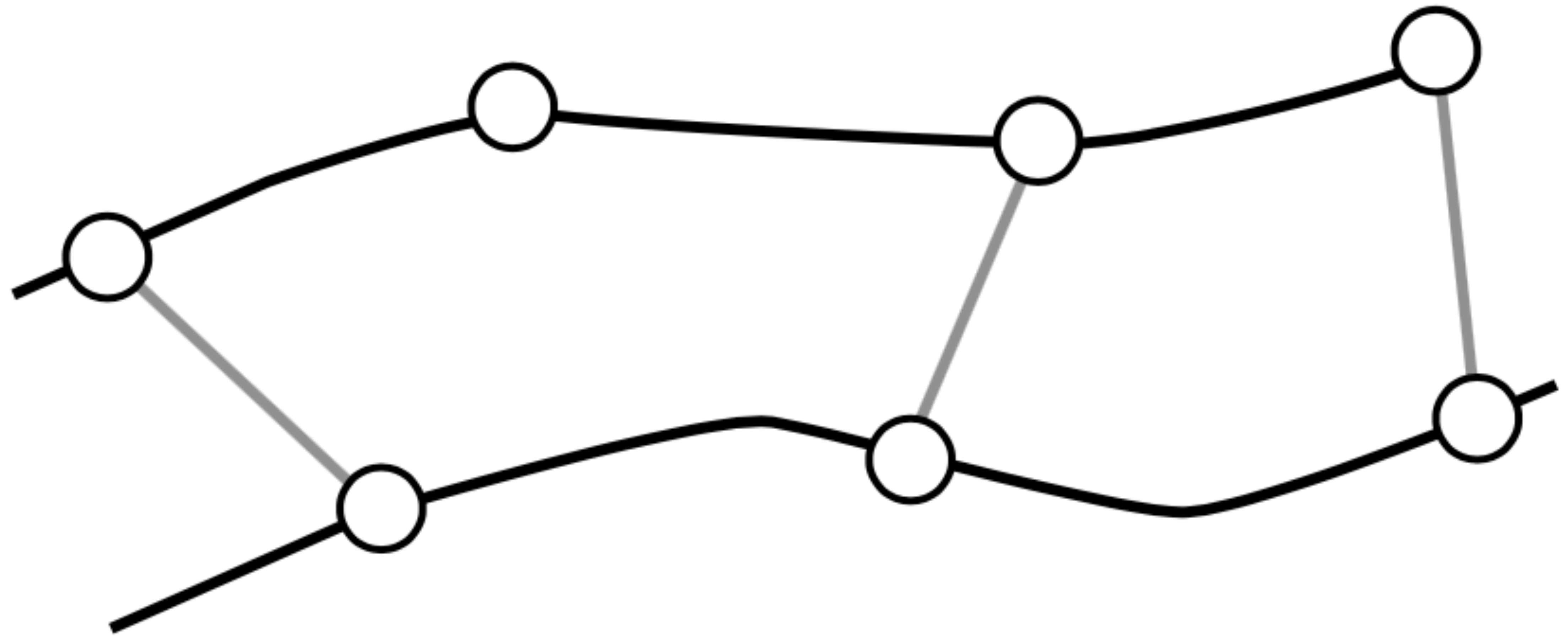
- Select (e.g., 1000) random points
- Match each to closest point on other scan, using a spatial data structure
- Reject pairs with distance > *k* times median
- Construct error function:

$$E := \sum_i (R\mathbf{p}_i + t - \mathbf{q}_i)^2$$

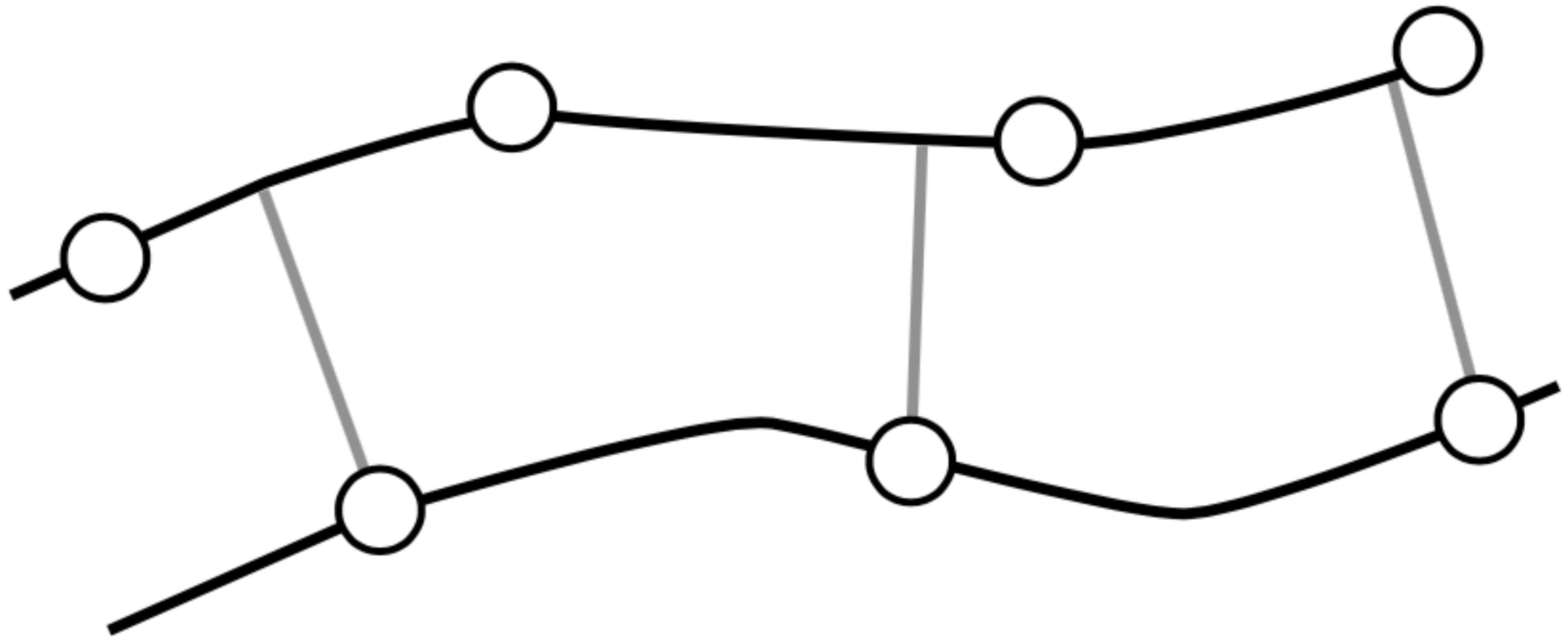
- Minimize (closed form solution in "Estimating 3-D rigid body transformations: a comparison of four major algorithms", http://dl.acm.org/citation.cfm?id=250160)

.

Important Variant



Point-to-Point



Point-to-Plane

See http://resources.mpi-inf.mpg.de/deformableShapeMatching/EG2012_Tutorial/ for details

References

- http://resources.mpi-inf.mpg.de/deformableShapeMatching/EG2012_Tutorial/
- http://mesh.brown.edu/byo3d/