CS348C – Winter 1997

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Range Acquisition
Part I: Introduction + Non–optical Methods

Outline:

1. Range acquistion strategies

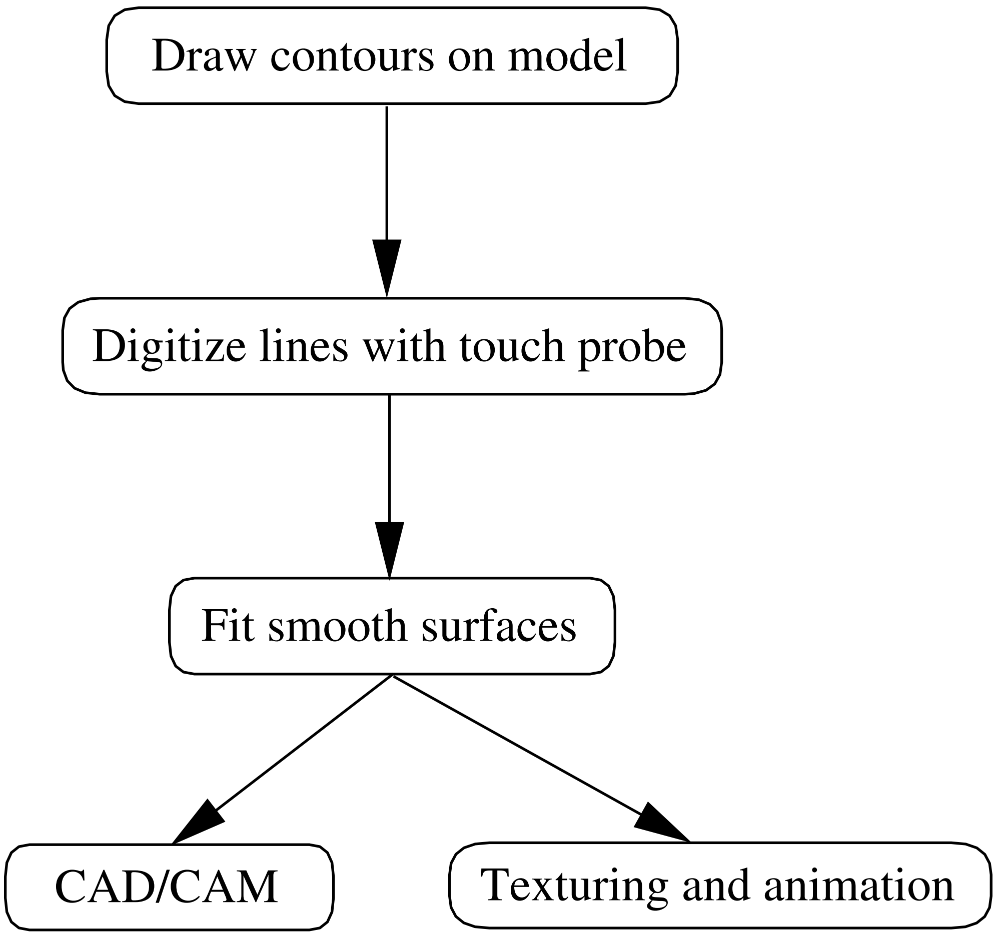
2. Structure of data

3. Quality measures

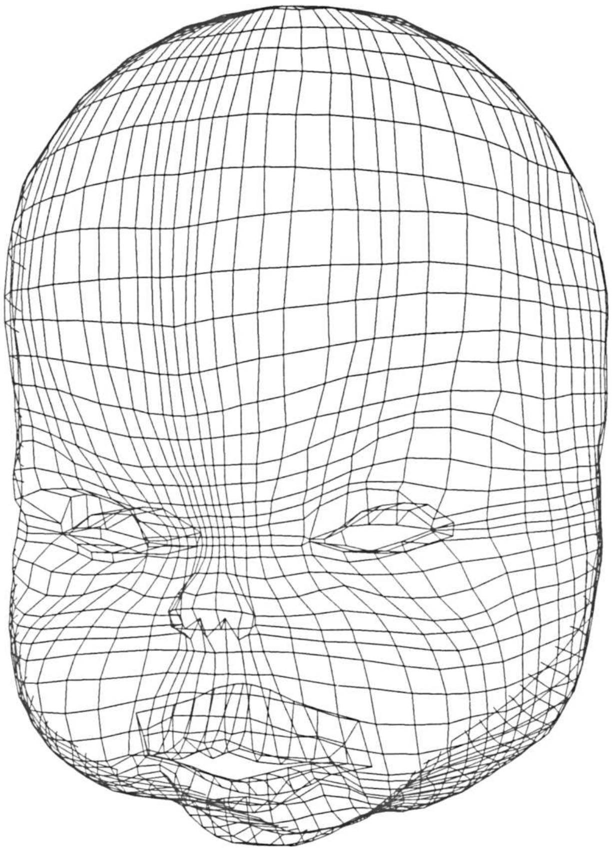
4. Contact–based range measurment
   – CMM, jointed arms
   – Polhemus

5. Transmissive range measurement
   – Industrial CT

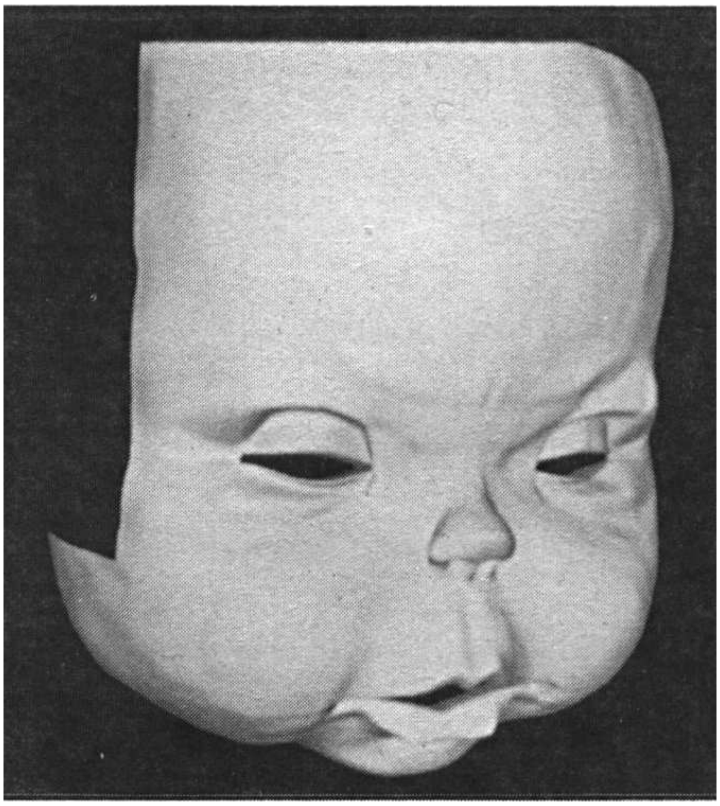
A "traditional" pipeline for shape capture



Example: Tin Toy



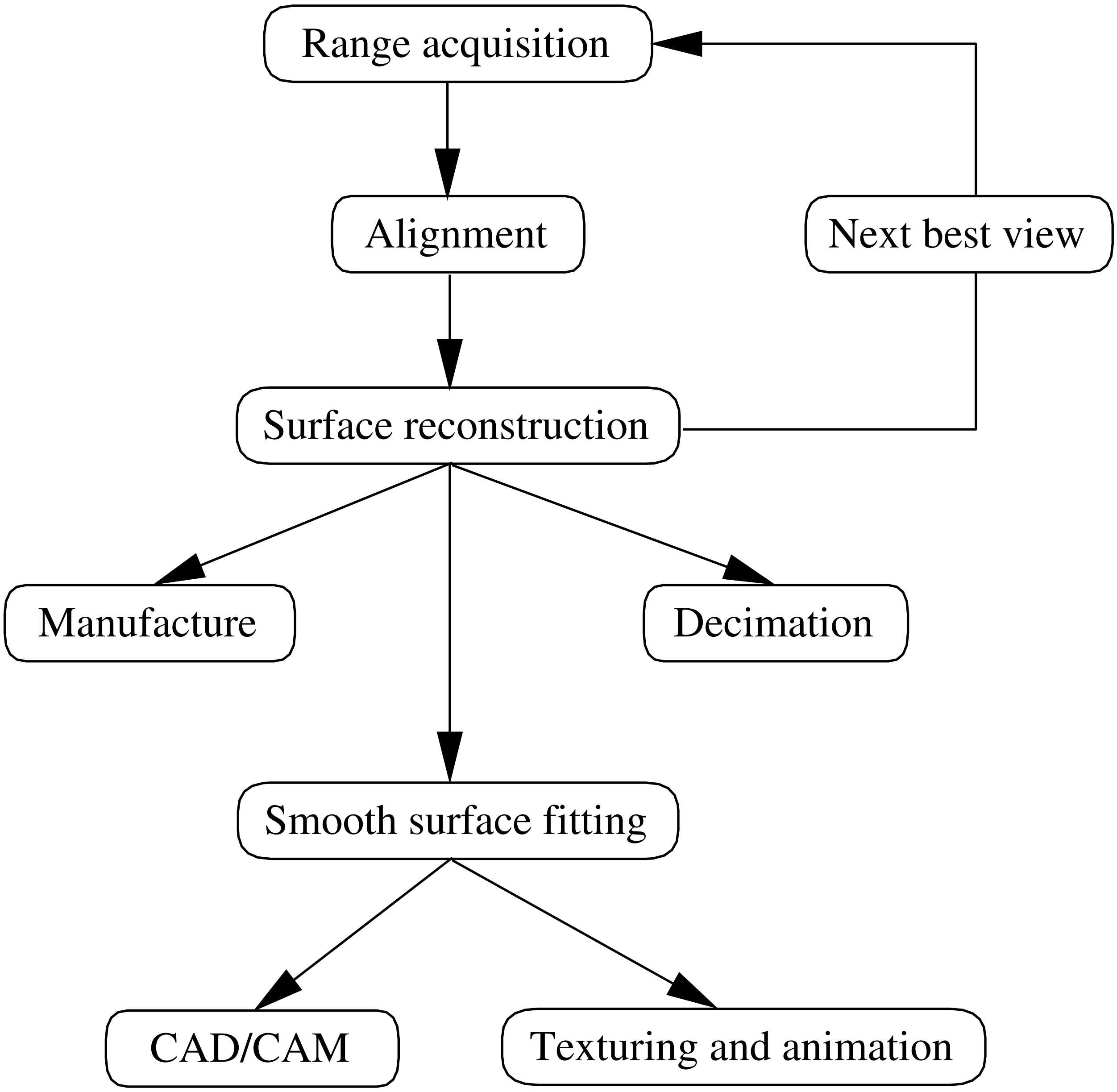
Digitized parameter lines



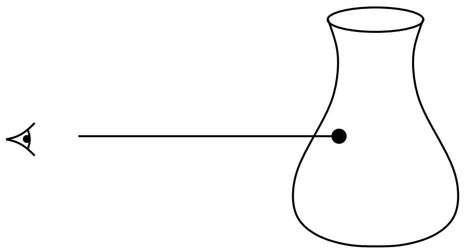
B−spline mesh

[Figures from Reeves 1990]

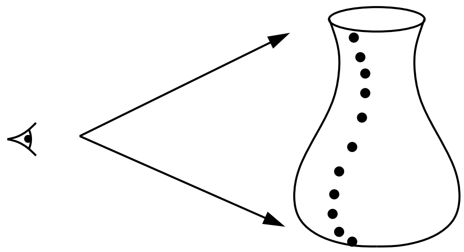
A "new" pipeline for shape capture



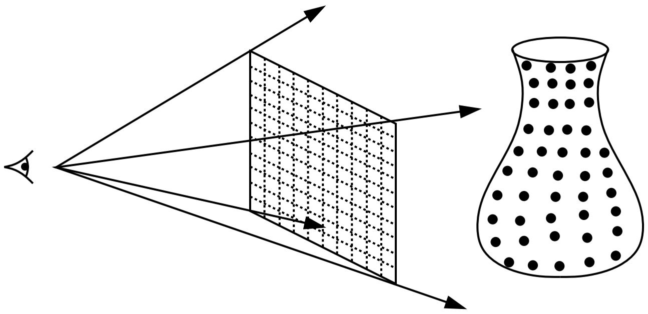
Structure of data



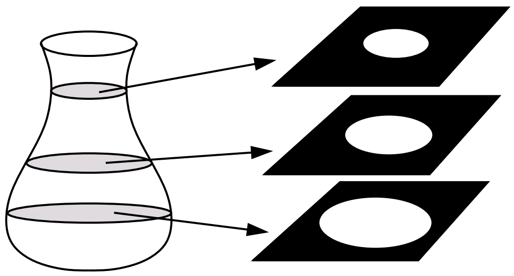
Point



Profile



Range image



Volumetric

Quality Measures

1. Resolution
   – The smallest change in range that the range sensor can report. How many bits of quantization? How far apart are samples?

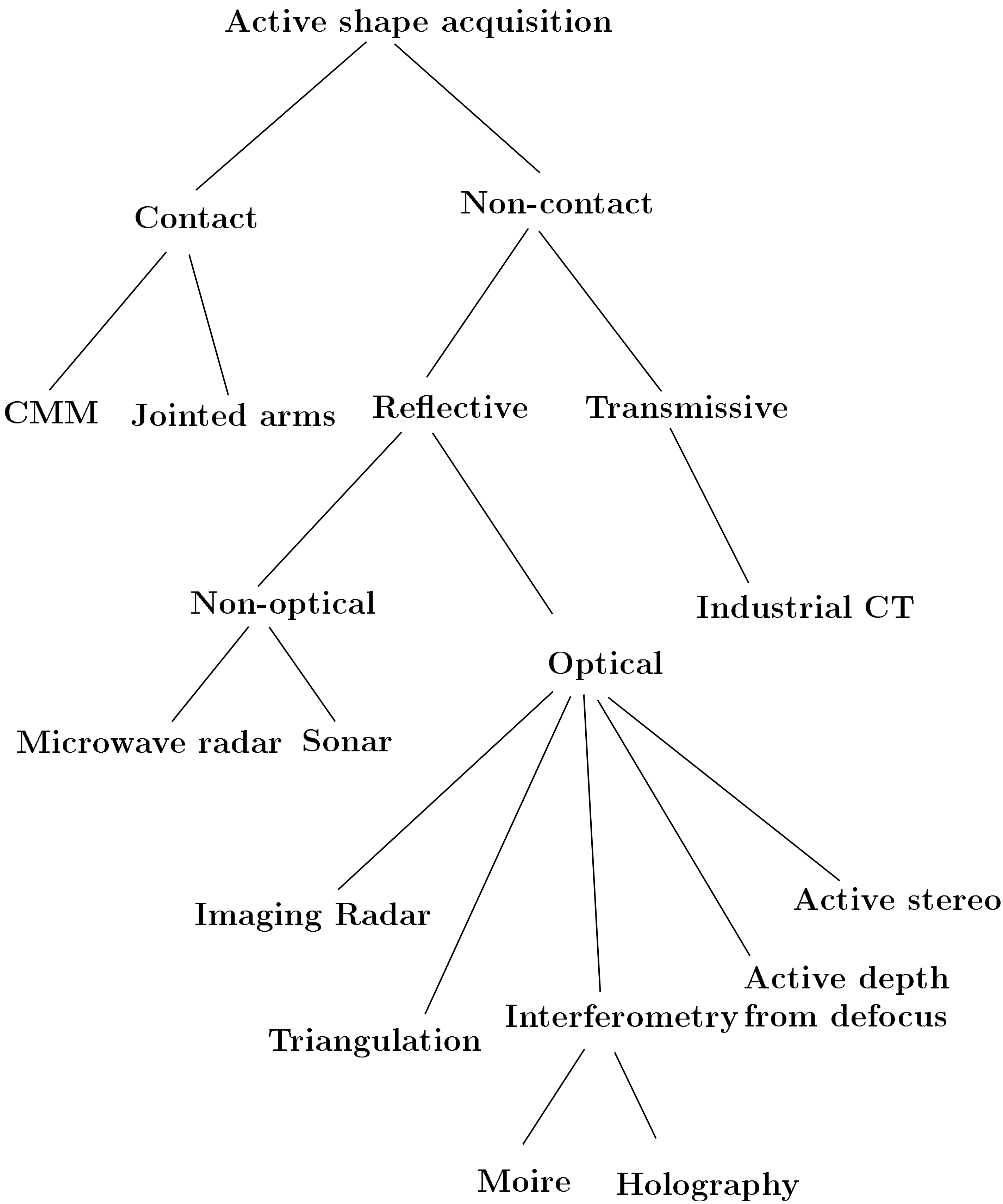
2. Repeatability
   – Statistical variations as a range sensor makes repeated measurements of the same point over time. Do the results tend to drift with usage?

3. Accuracy
   – Statistical variations as a range sensor makes repeated measurements of a known true value. Usually characterized as standard deviation, σ. Manufacturers may report σ, 2σ, or 3σ. Specifications are frequently "not to be exceeded".

4. Environmental sensitivity
   – Does accuracy vary with temperature? Wind speed?

5. Speed
   – Points per second (seconds per point??)
   – Off–line real–time
   – True real–time
   – What would you do with a real–time range imaging sensor?

A taxonomy of active range acquisition



Contact Methods: Mechanical

Coordinate Measuring Machine (CMM)

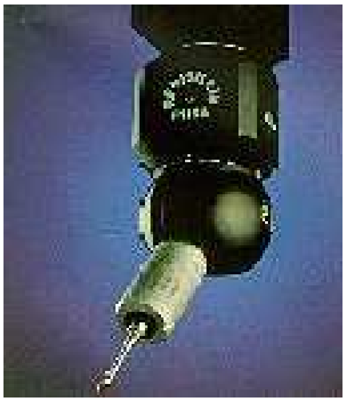
Principle:

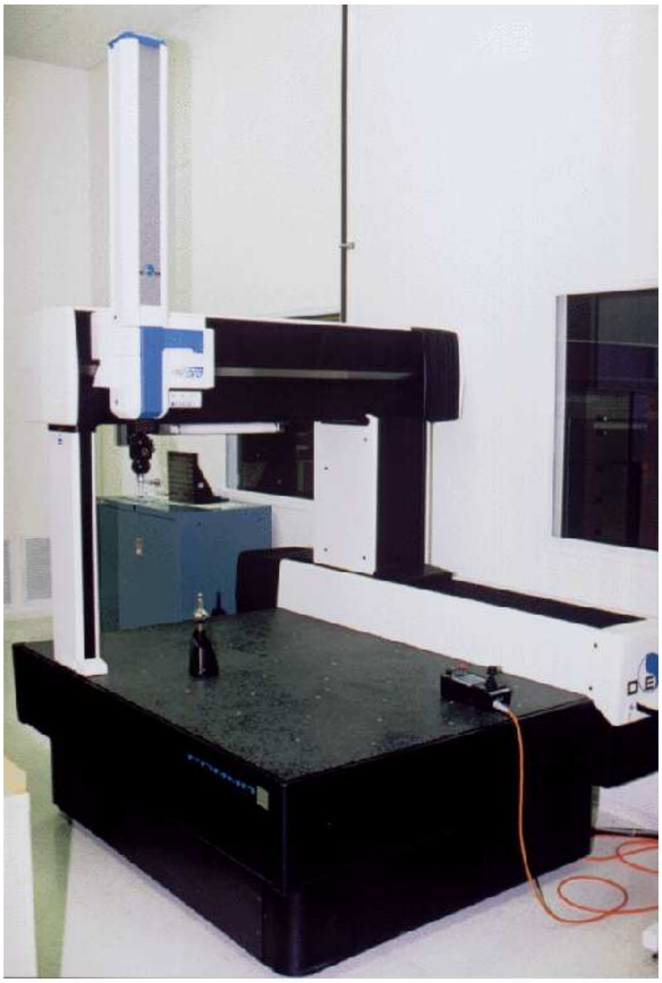
Typically use X,Y,Z translation assembly with optical gratings to measure displacements. The probe may have a rotational degree of freedom and is specially calibrated to measure point of contact.

Working volume:
  1–5 meters

Accuracy:
  10 microns in 1 meter => 1 part in 100,000 accuracy!

Notes:
- Expensive
- Slow





Overall view of coordinate measuring machine

[Images from National Center for Excellence in Metalworking Technology – http://www.ncemt.ctc.com/thrustAreas/forming/ssm/workcell/measure.html]

Contact Methods: Mechanical

Jointed arms

Principle:

A series of rotating joints provide freedom of movement. A sequence of joint to joint transformations provide position and orientation of the stylus.

[The following are statistics for a *FaroArm*.]

Working volume:
  2.4 meters

Accuracy (2σ):
  0.1 mm or 1 part in 24,000 (Sliver series)
  0.3 mm or 1 part in 8,000 (Bronze series – in our lab)

Notes:
- Much less expensive than CMM's
- Slow

[Image from Faro's web pages – http://www.faro.com]

Contact Methods: Magnetic trackers

Principle:

A transmitter sends multiple magnetic field pulses, and a receiver detects the pulses. Based on the strengths of the receiver responses, the position and orientation of the transmitter source is computed.

[The following are statistics for the *Polhemus FastTrak.*]

Working volume: 3−10 meters

Accuracy:
0.75 mm and 0.15 degrees => ~1 part in 5000 positional accuracy

Notes:
- Wireless versions available for motion tracking
- Sensitive to metals and magnetic sources (monitors)

Transmissive: Industrial CT

Principle:

A series of line X−rays are taken at many angles within a plane to obtain a density profile of one object slice. The object is translated through the scanner one slice at a time. The result is a volumetric description of the object.

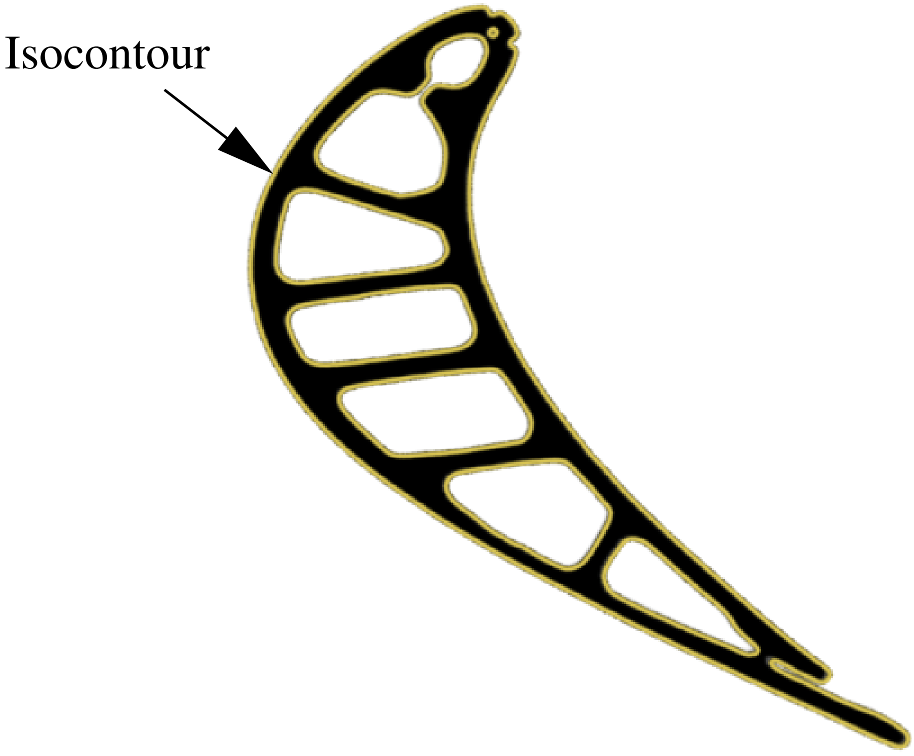
The surface is an implicit function, a level set at F(x) = C within the volume. Isosurface extraction algorithms can obtain the desired surface.

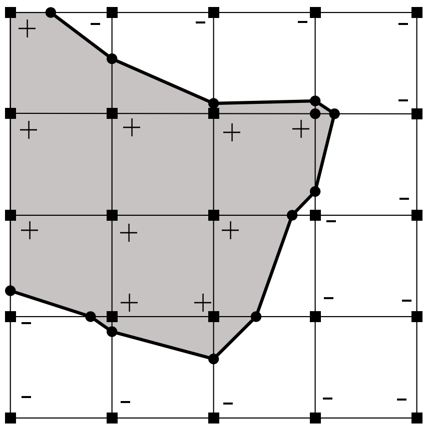
Working volume:
  0.2 – 2 meters

Accuracy:
  0.25 mm voxel spacing (in 0.2 meters)

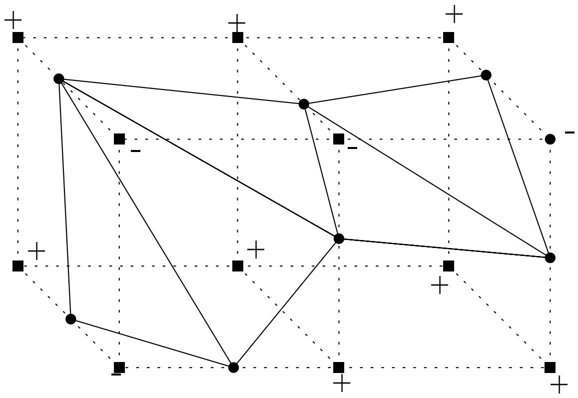
Notes:
- Acquires internal cavities
- Very expensive
- Uses hazardous radiation
- Accuracy varies with large variations in material densities – e.g., wood glued on metal

[Images courtesy Bill Lorensen, General Electric Corporate R&D]





Isocontour from "marching squares"



Isocontour from "marching cubes"

[Image courtesy Bill Lorensen, General Electric Corporate R&D]

Bibliography

Reeves, W. "Simple and complex facial animation: case studies." *State of the Art in Facial Animation*, ACM SIGGRAPH course notes 26, Dallas Texas, August 6–10, 1990.