3D Modelling

Lecture 7
Acquisition Techniques

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Outline

Acquistion techniques

Central issue

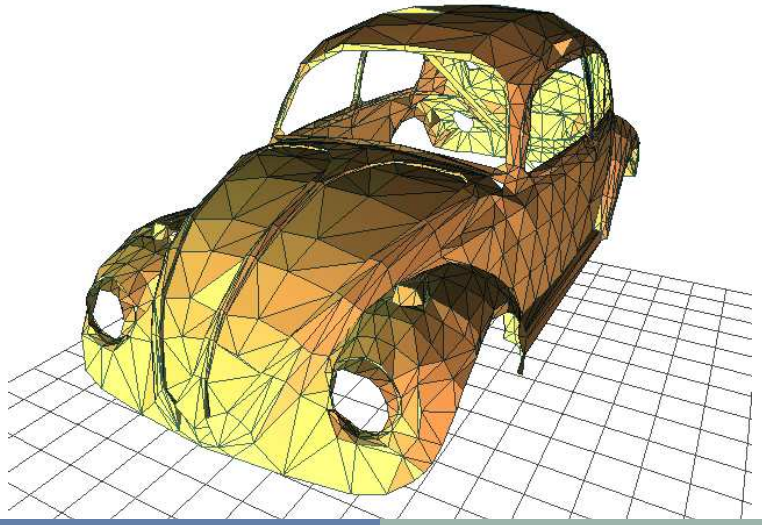
How do we get shapes from the real word into a computer?

Answer

With lots and lots of effort :-)

Non-automatic: tape measure

1972: the Utah Volkswagen Beetle



Non-automatic: tape measure

- measured by four graduate students
- pole & pavement were reference system
- measured using yardsticks
- assumed to be symmetric: so measured only half the car
- each student did a few parts
- joining the parts revealed errors
- mirroring the parts produced gaps
- creating the model cost more than the car

Non-automatic: measure & Bézier curves

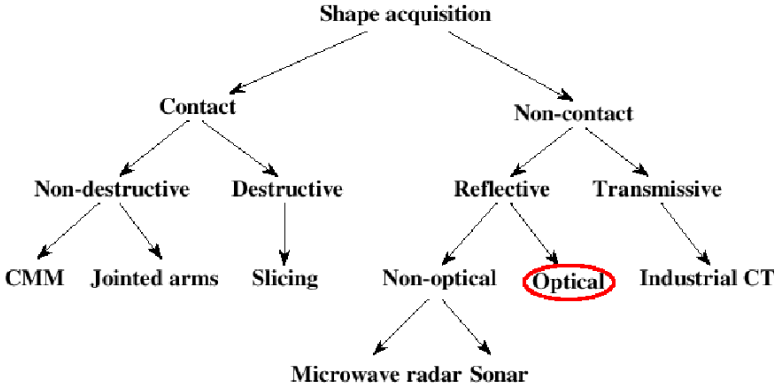
1975: the Utah Teapot

- Bézier curves constructed by hand (by Martin Newell)

Why did it become so popular?

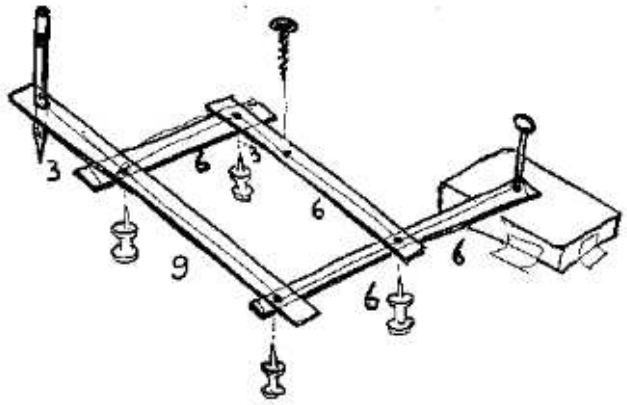
- it's instantly recognisable
- it has complex topology
- it self-shadows
- it has convex and concave surfaces, and 'saddle points'
- it doesn't take much storage space
- modelling is hard (especially back then)

(Semi-) automatic 3D acquisition methods



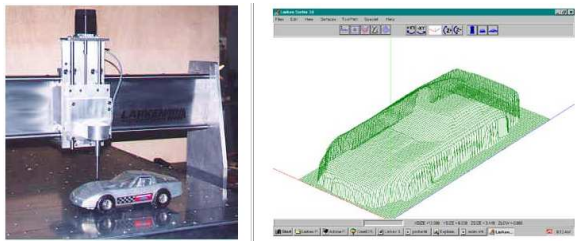
images c/o SIGGRAPH 2000 course "3D Photography", B. Curless & S. Seitz

a Coordinate Measuring Machine: Pantograph



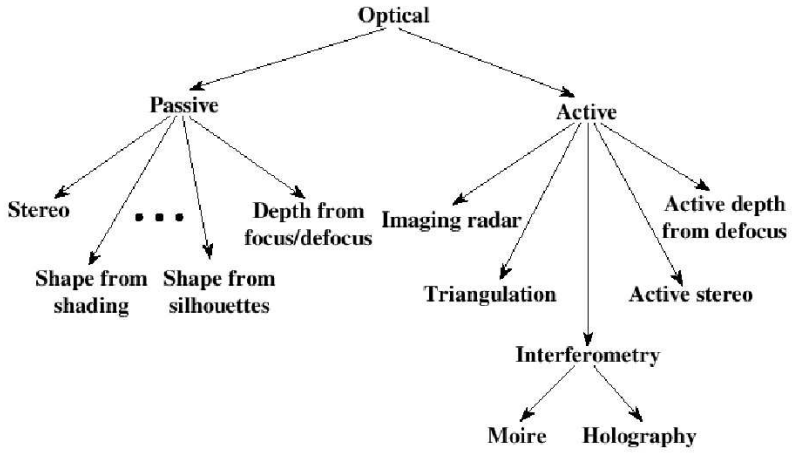
a Coordinate Measuring Machine: 3D Probe

"Larken 3D Probe"



there exist probes with 5 nm resolution!

(Semi-) automatic 3D acquisition methods: optical



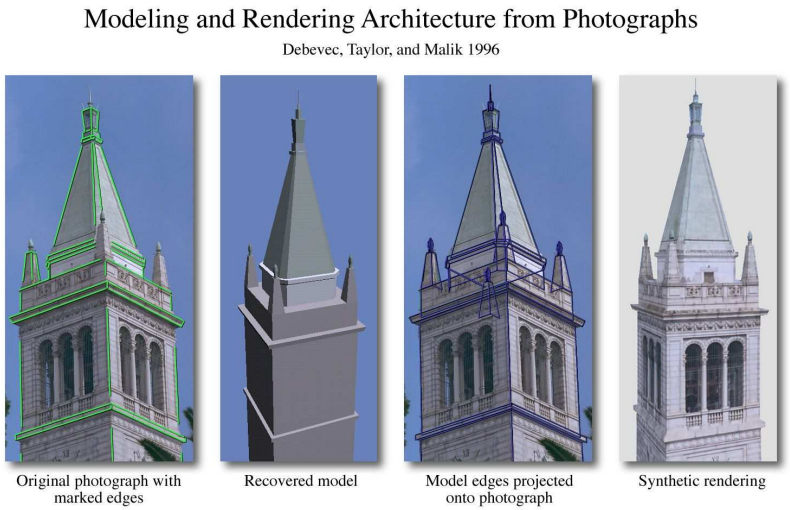
images c/o SIGGRAPH 2000 course "3D Photography", B. Curless & S. Seitz

Image-based techniques

Use photographs, and reconstruct shape from:

- motion: find correspondences in consecutive image
- stereo: find correspondences in images from multiple viewpoints
- shading: assuming uniform reflection
- texture: assuming uniform textures
- contour: assume edge-delimited object, find and connect them

Shape from contour



images c/o Paul Debevec

Shape from stereo

find correspondences in images from multiple viewpoints (here 2)

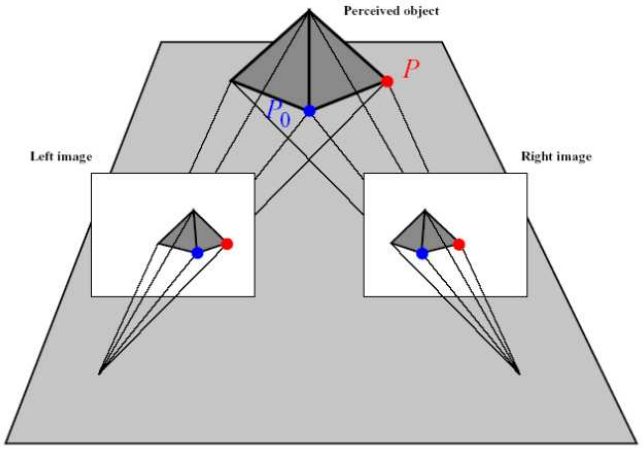


image c/o University of Chicago

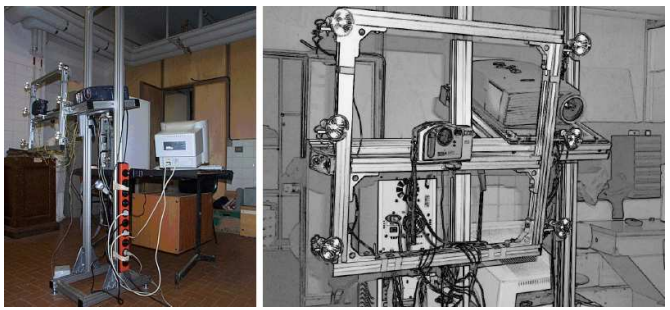
Shape from shading

- *left:* original photograph
- *middle:* reconstructed elevation surface
- *right:* rendering of this surface under similar lighting

Clementine spacecraft, lunar mission, 1994

Structured light

- assume the scene is one object, and the object is static
- project known light patterns onto the object, and find edges of these patterns in the recorded image



images c/o C. Rocchini, CNR-ISTI, Italy

Structured light: triangulation

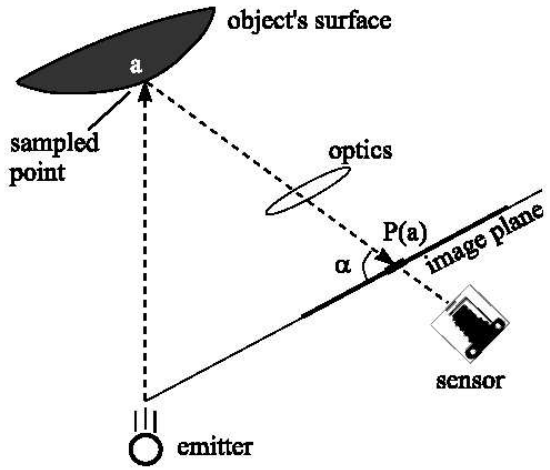
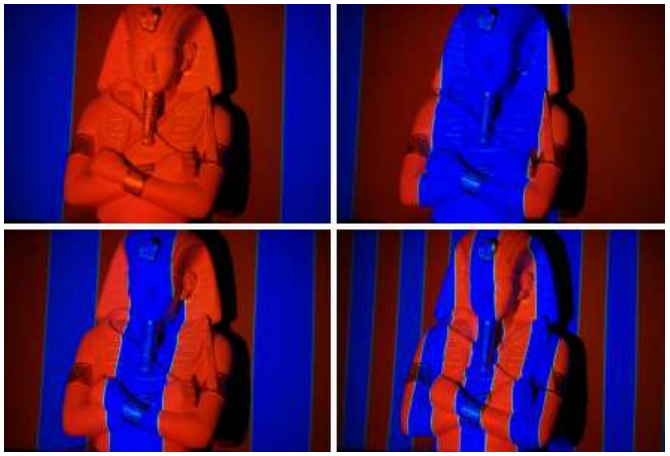


image c/o C. Rocchini, CNR-ISTI, Italy

Structured light

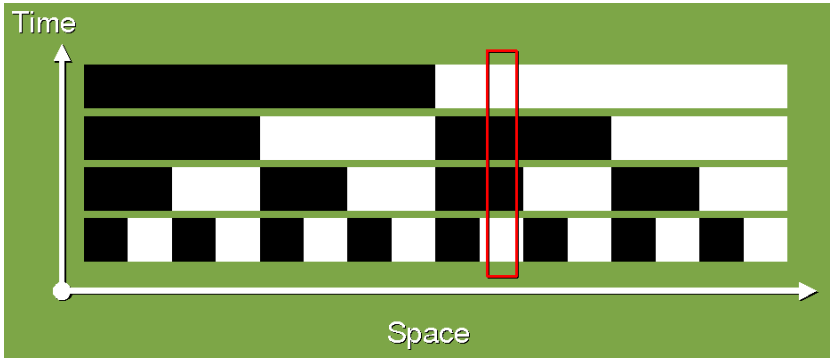


→ improve identification by sending out stripes that vary in color and over time

image c/o C. Rocchini, CNR-ISTI, Italy

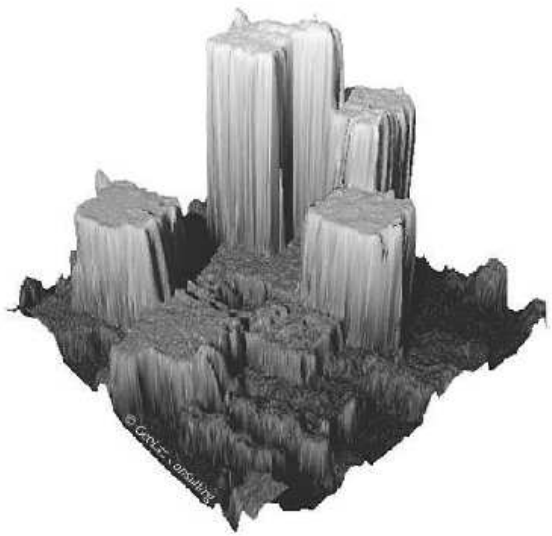
Structured light

- variation over time: time-coded light patterns [Posdamer 82]
- so identify a point by its "time-code"

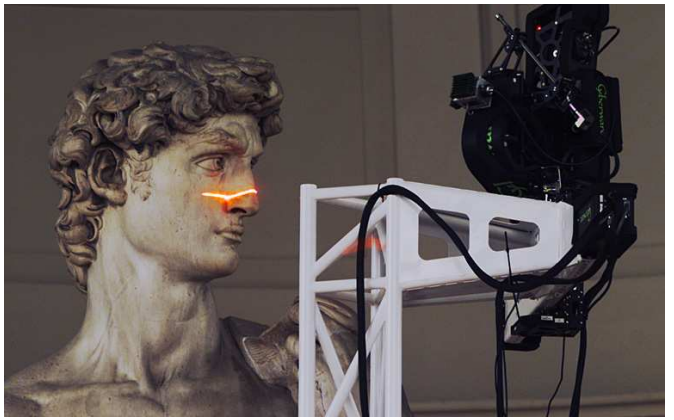


Time of flight scanner

send out a pulse of light (usually laser), time how long it takes to return

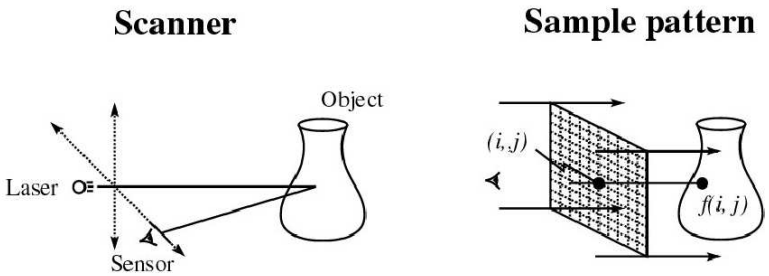


Triangulation scanner: laser range scanner



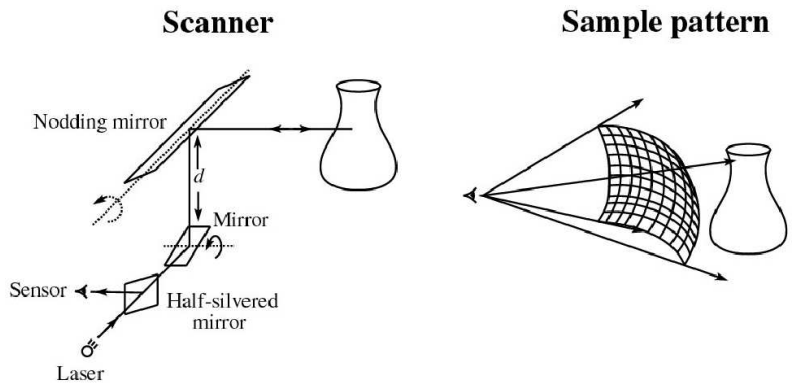
Digital Michelangelo project, Stanford computer graphics group

Scanning patterns



images c/o Brian Curless

Scanning patterns



images c/o Brian Curless

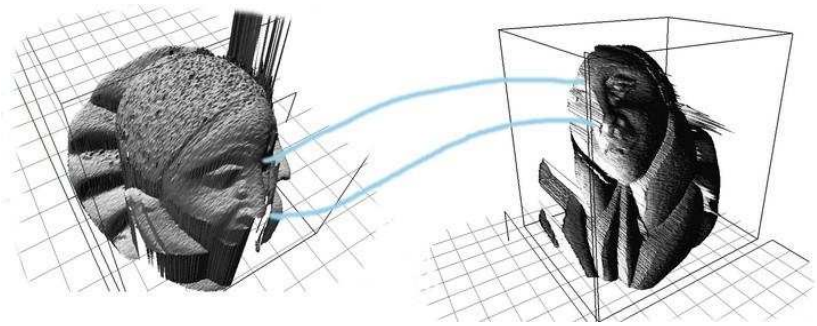
The next step: surface reconstruction

How to reconstruct a 3D model from range data?

range data c/o CNR-ISTI

Surface reconstruction: range-scan alignment

How to reconstruct from multiple range scans?



- The initial alignment is done by hand, or by specifying *feature correspondences*
- The "fine" alignment is done using a method like ICP

Range-scan alignment

popular method: Iterative Closest Point (ICP) [Besl & McKay 1992]

- for each point on one scan, minimize distance to closest point on other scan
- and iterate until convergence
- problem with ICP: local minima, only works well when initial scans are close together
- improvements have been developed

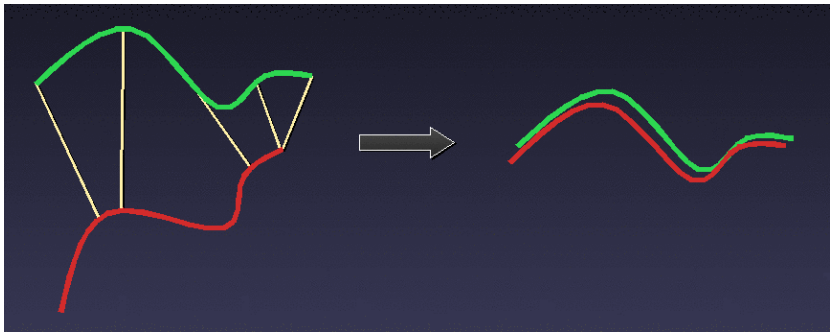


image c/o Szymon Rusinkiewicz

Introduction
Acquisition techniques
Surface reconstruction
Range-scan alignment

Range-scan alignment

popular method: Iterative Closest Point (ICP) [Besl & McKay 1992]

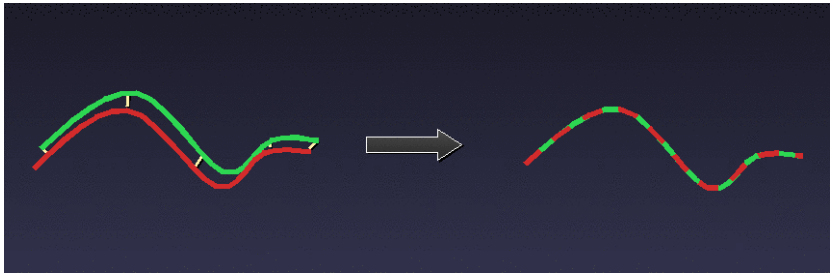


image c/o Szymon Rusinkiewicz

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Introduction
Acquisition techniques
Surface reconstruction
Range-scan alignment

Relevant reading

From the paper "Zippered Polygon Meshes from Range Images" by G. Turk and M. Levoy:

- section 1: Introduction
- section 3: Structured Light Range Scanners
- section 4: Registration of Range Images (except 4.3 and 4.4)

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