中国科学技术大学
University of Science and Technology of China

计算机图形学
Computer Graphics

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Introduction: Geometric Modeling

- Motivation
- Overview: Topics
- Basic modeling techniques

Geometric Modeling

- Start with a blank screen, design a geometric model
- Challenge: mathematical description of shape information
  - Computer friendly
  - User friendly
- Typical techniques:
  - Spline curves & surfaces
  - Constructive solid geometry (CSG)
  - Subdivision surfaces

Geometric Modeling

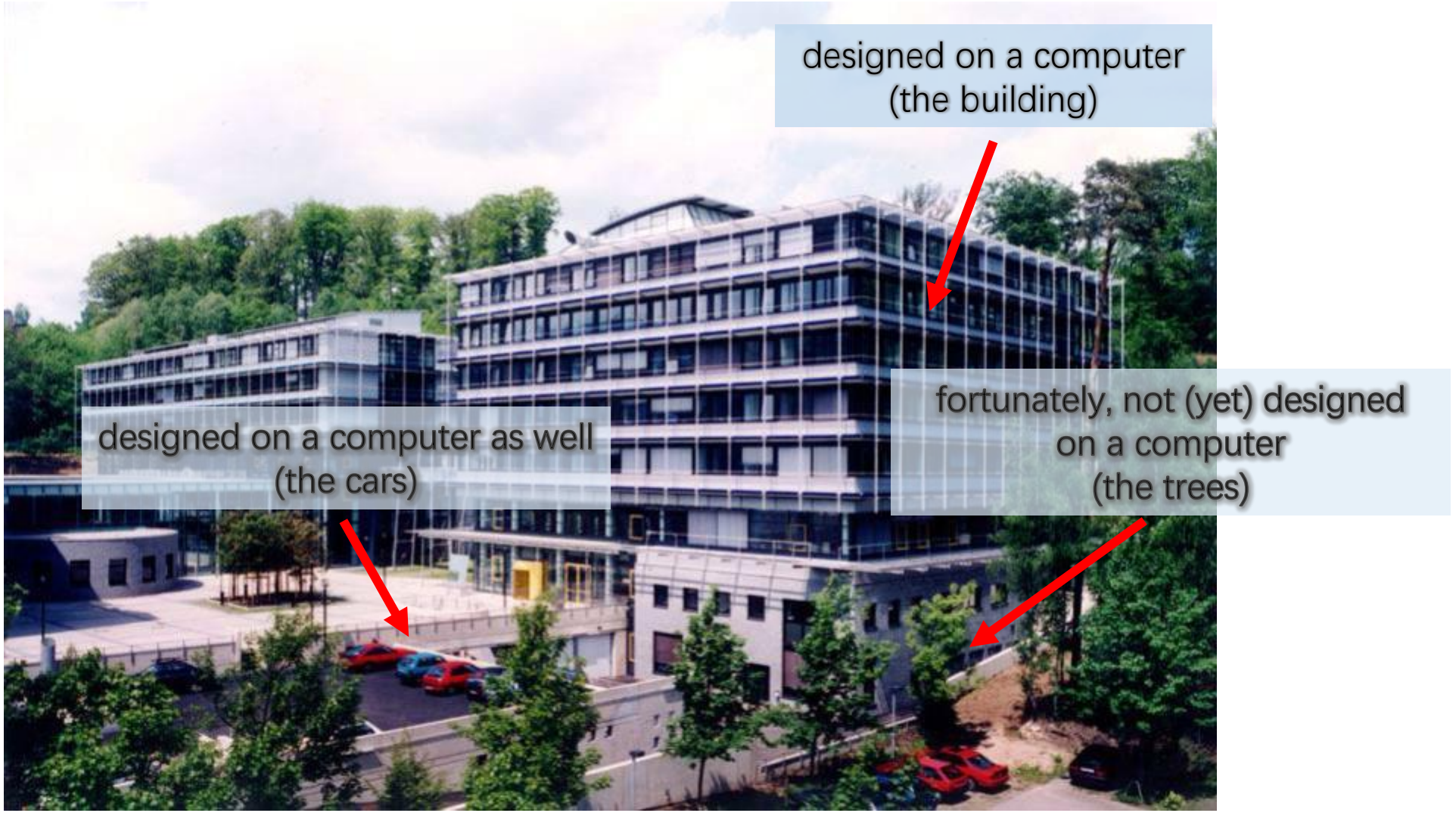
Geometric Processing

- A (discrete) sampling of the model is readily available
  - Typically: 3D scanner (point cloud)
- Challenge: make sense of large complex, unstructured data
  - Analyze and edit the geometry
- Typical issues
  - Noise removal, filtering
  - Surface reconstruction
  - Analysis (features, symmetry, hole-filling, etc…)
  - Parameterization (mapping textures)
  - Editing, deforming

Examples

Geometric Modeling

The Modern World···



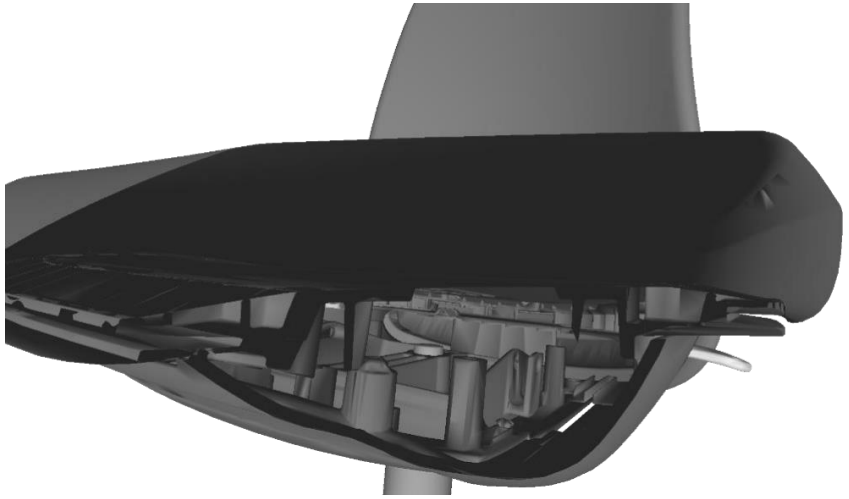
Impact of Geometric Modeling

We live in a world designed using CAD

- Almost any man-made structure designed w/computers
  - Architecture
  - Commodities
  - Bike, car
  - Spline curves inverted in automotive industry
  - Fonts
- Our abilities in geometric modeling shape the world we live in each day

Different Modeling Tasks

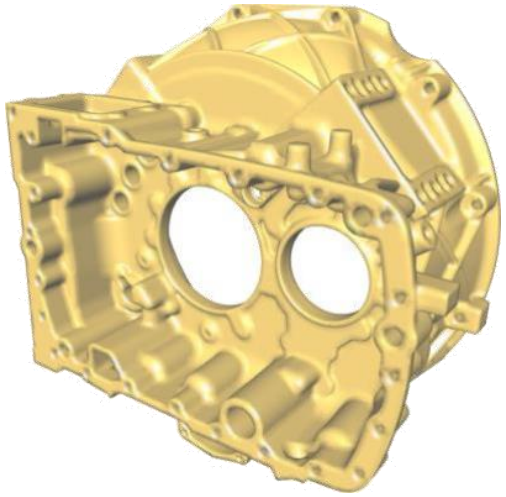
Different requirement for different setups

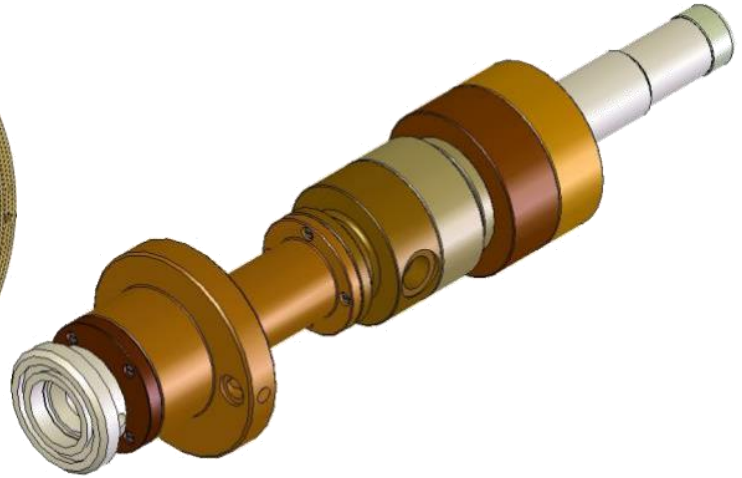
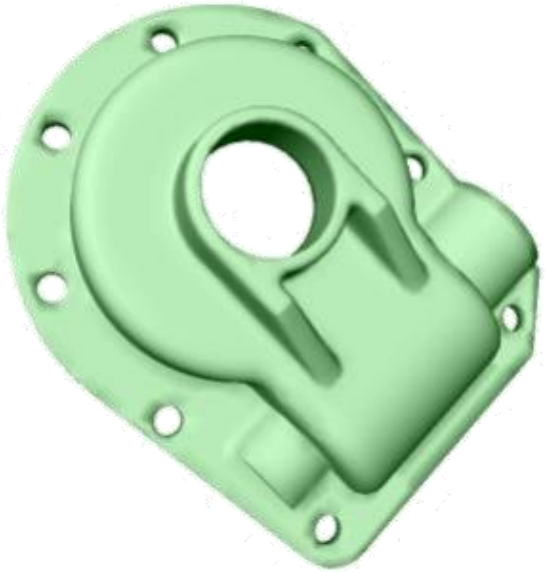


Different Modeling Needs

CAD / CAM

- Precision Guarantees
- Handle geometric constraints exactly (e.g. exact circles)
- Modeling guided by rules and constraints

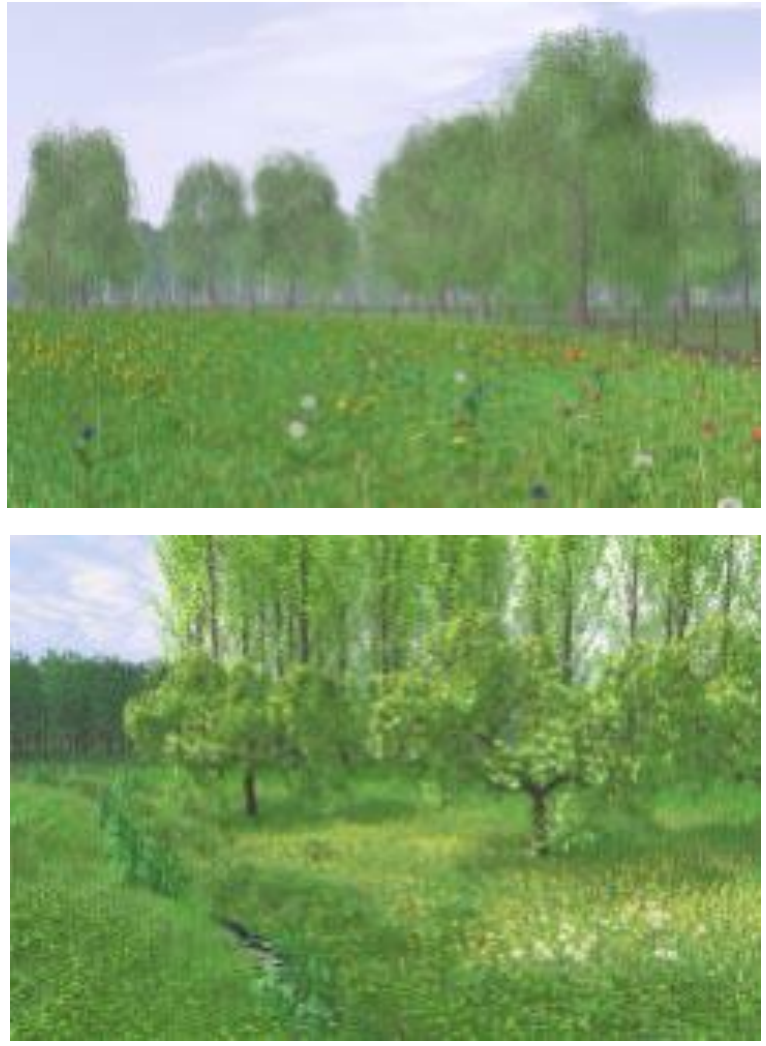


Different Modeling Tasks

Photorealistic Rendering

- Has to “look” good
- Ad-hoc techniques are ok
- Using textures & shaders to “fake” details
- More complexity, but less rigorous



[Deussen et al: Realistic modeling and rendering of plant ecosystems, SIGGRAPH 1998]

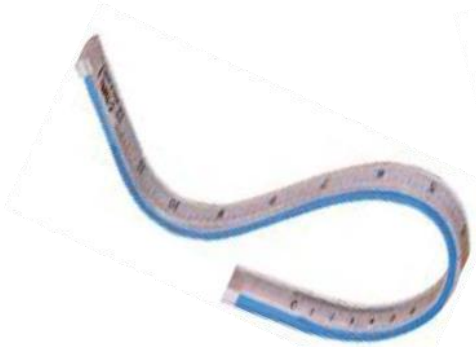
Geometric Modeling

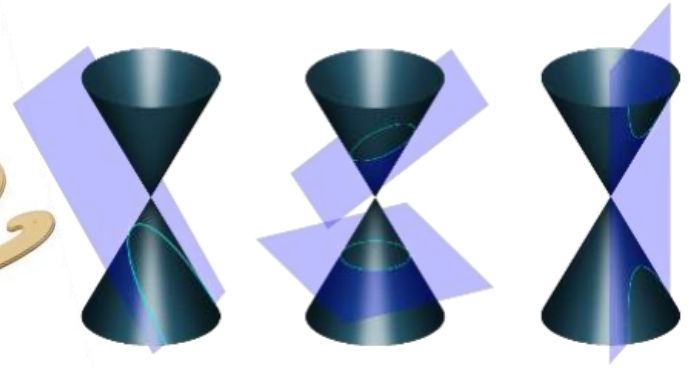
A look back

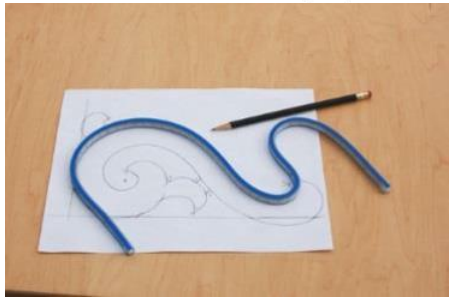
Modeling the old way

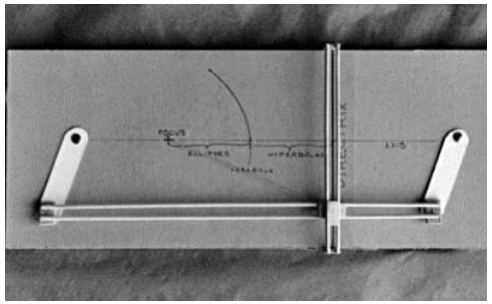
Basic tools

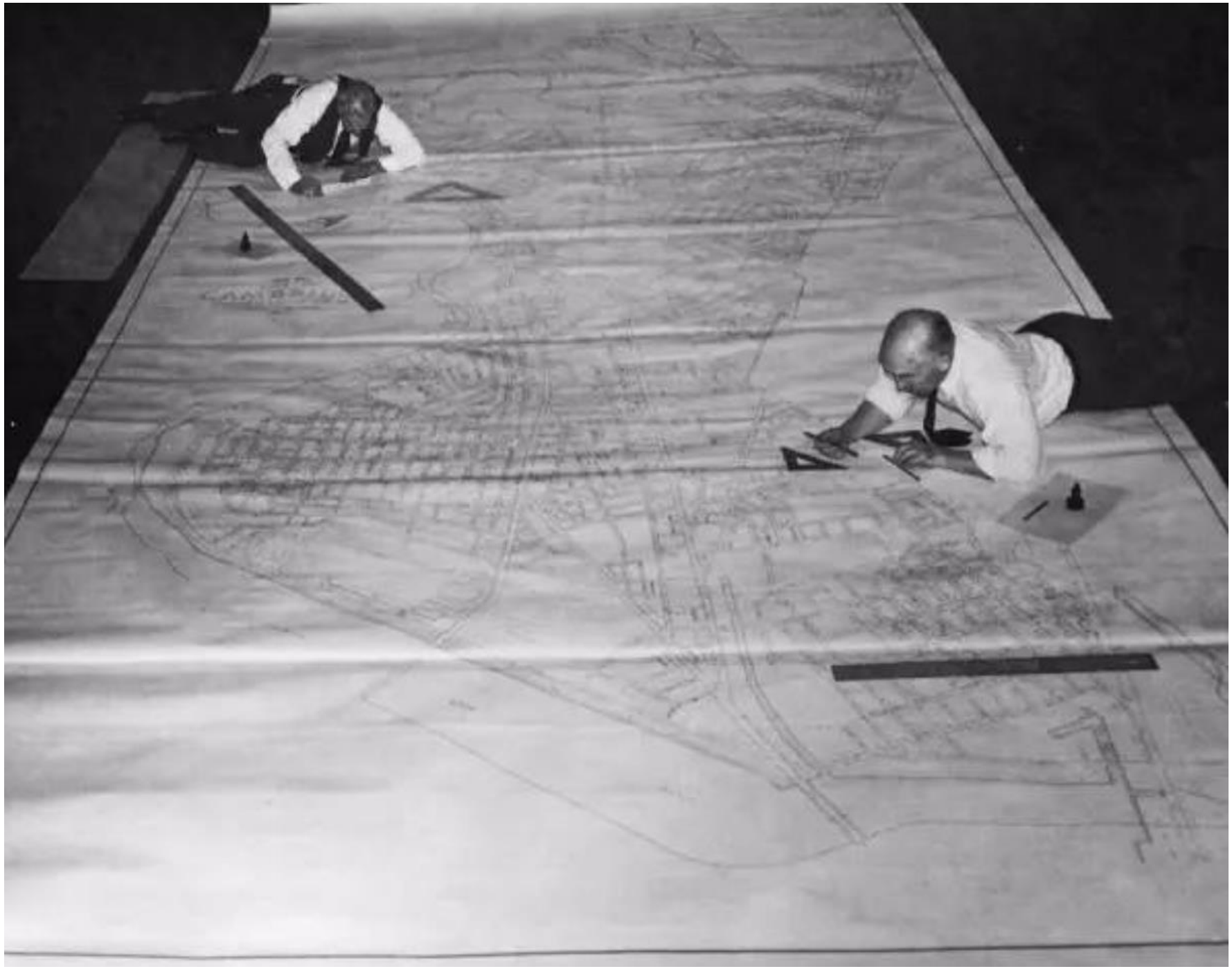
- Measuring and drafting tools



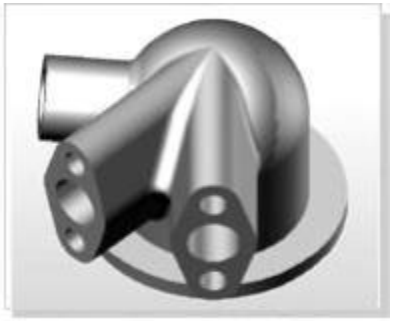


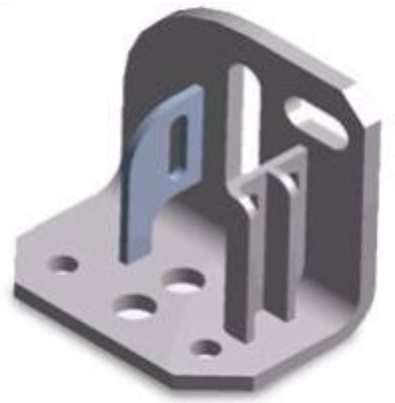


Industrial modeling developments

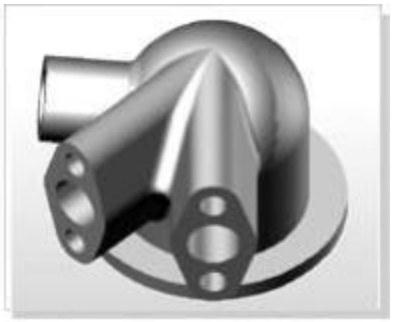
Industrial modeling: Two distinct shape classes

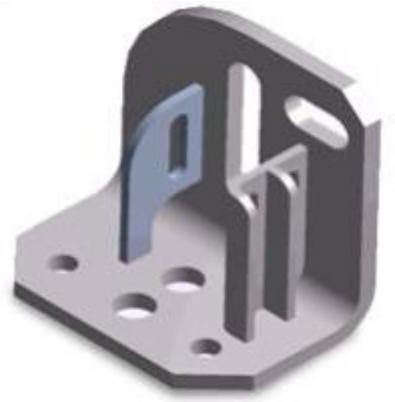
- Complex combination of elementary surfaces
  - Easy to model (blueprint)
  - Easy to produce
  - Easy technical evaluations (volume, moment of inertia)





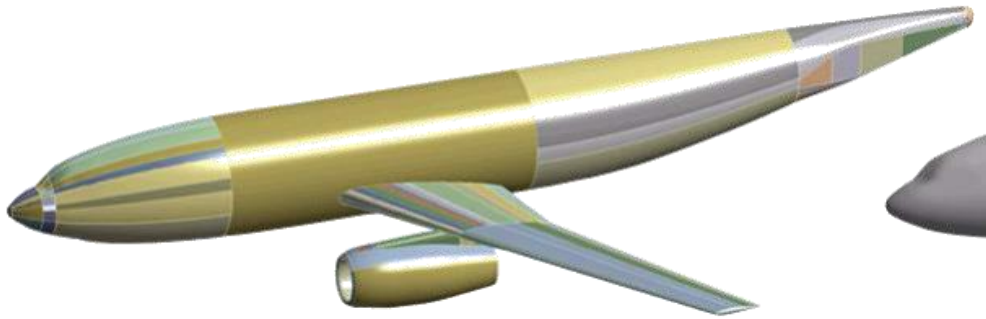
Industrial modeling developments





Industrial modeling: Two distinct shape classes

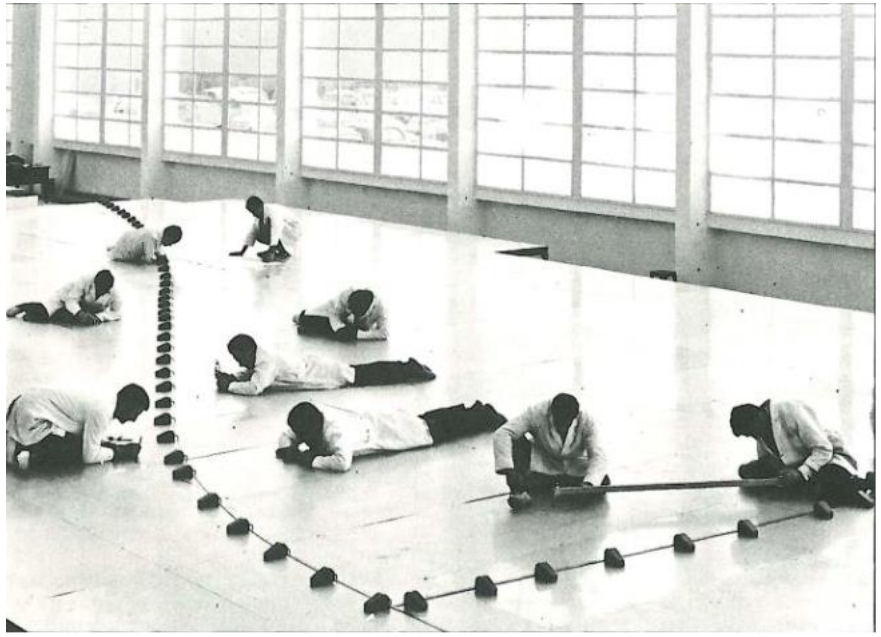
- Complex combination of elementary surfaces
  - Easy to model (blueprint)
  - Easy to produce
  - Easy technical evaluations (volume, moment of inertia)
- Free-form shapes
  - Required mainly by modern industries e.g. aeronautics, shipbuilding, auto industry
  - Not easy to describe mathematically
  - Harder technical evaluations

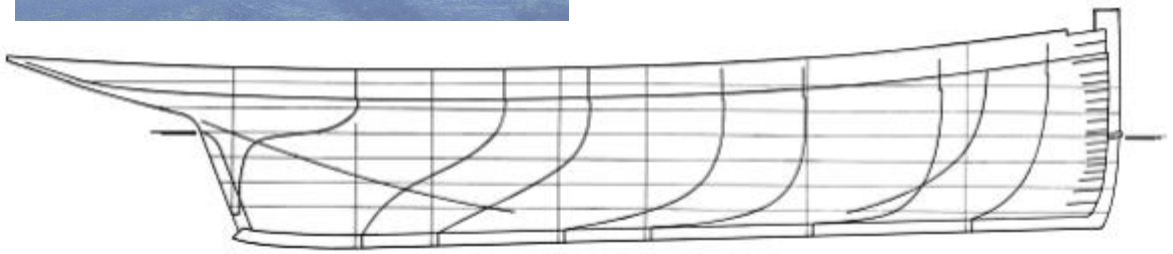


Early modeling of free-form curves and surfaces

Splines

- Thin flexible band made out of wood, plastic or steel
- Can be held in shape using weights
- Smooth energy minimizing curves

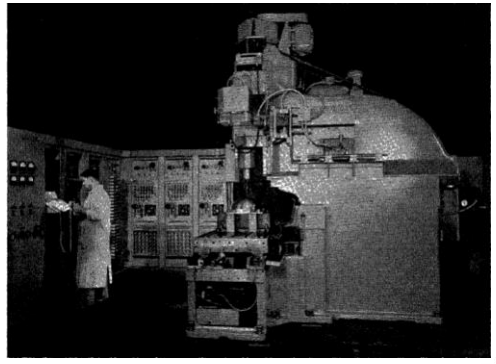


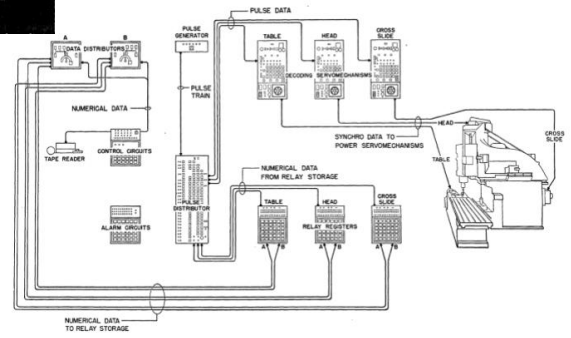


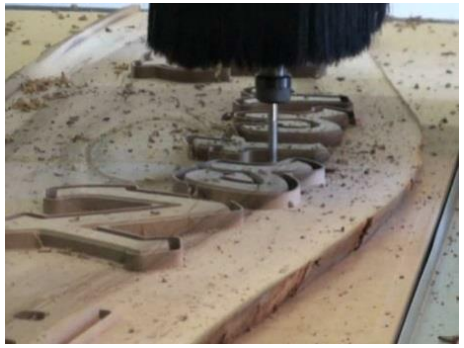
Birth of computer aided design (CAD)

Two major events

- The world's first NC 3D milling machine (MIT 1951)
  - Shapes can be described mathematically
  - Read shape information from drawing



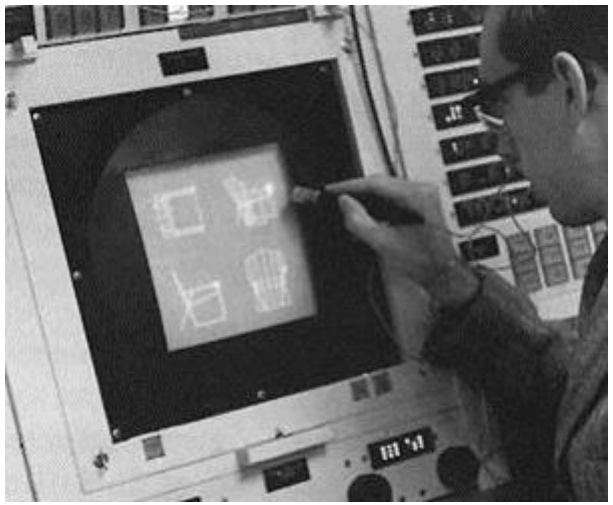


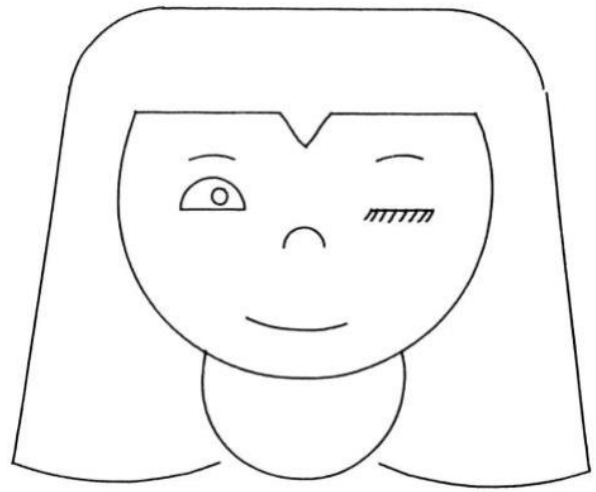


Birth of computer aided design (CAD)

Two major events

- I. Sutherland sketchpad: A man machine graphical communication system (MIT 1963)
  - Shape became visible (Not just a formula)
  - Direct interaction with shape





Birth of computer aided design (CAD)

Development of mathematical descriptions of Free form curves and surfaces

- Ferguson curves and surfaces (Boeing 1961)
  - Vector description and use of parameters
- Coon surface patches (MIT 1964)
  - Control through positions and tangents

- de Casteljau Algorithm (Citroën 1959)
- Bézier curves (Renault 1971, UNISURF system)
- B-splines, NURBS, T-splines,…

Thank you!

Questions?