Geometric Modeling

Creating 3D solid geometry in a computer!
Partial History of Geometric Modeling

1963 **Wireframe** Computer Graphics “Invented” (Ivan Sutherland, MIT)
Partial History

1964
DAC-1, General Motors
# Partial History of Geometric Modeling

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
<th>Details</th>
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<tr>
<td>1967</td>
<td>Surface Modeling</td>
<td>(S.A. Coons)</td>
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<td>1973</td>
<td>Solid Modeling – <strong>Constructive Solid Geometry</strong></td>
<td>(Laning et al., Draper Lab.)</td>
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<td>1973</td>
<td>Solid Modeling – <strong>Boundary Representation</strong></td>
<td>(Ian Braid, Cambridge U.)</td>
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<td>1985</td>
<td><strong>Feature Modeling</strong></td>
<td>(Pratt &amp; Wilson)</td>
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<td>1990</td>
<td><strong>Parametric Modeling</strong></td>
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Wireframe Modeling

• Stores positions of lines (in 2D or 3D)
• Helpful for drafting (easy multiple views and easy editing)
• Ambiguous surfaces limit the automation possibilities (e.g. no volume calculation, no NC tool path generation)
Surface Modeling

- Stores equations of surfaces
- Most 3D graphics libraries use surface modeling
- Good for visualizing complex surfaces and automated NC path generation of complex surfaces
- Material volume information is ambiguous or hard to determine (therefore can’t calculate volume)

From K., Lee “Principles of CAD/CAM/CAE Systems,” Addison-Wesley
Solid Modeling

• Various mathematical representations exist that each allow **point-set classification**: “Is a given point inside or outside the solid region?”

• Solid models can be used for:
  – volume calculations
  – Automatic FE mesh generation
  – Collision determination in robotics or NC path generation

MAE 455 Computer-Aided Design and Drafting
Solid Modeling Functions

Different ways that a user can create solid shapes:

- Primitive creation
- Boolean operations
- Sweep operations
- Surface/Transformation operations
- Engineering Feature-Based modeling
- Parametric modeling
Primitive Creation

- Primitives are simple solid shapes with simple mathematical surfaces
- Can be controlled by a small number of dimension and position parameters

From K. Lee “Principles of CAD/CAM/CAE Systems,” Addison-Wesley
Boolean Operations

• Boolean operations are used to make more complicated shapes by combining simpler shapes

• 3 types of operations are possible:
  – union (‘∪’) or “join”
  – intersection (‘∩’)
  – difference (‘−’) or “subtract”

• Be careful:

From K. Lee “Principles of CAD/CAM/CAE Systems,” Addison-Wesley
Sweeping Operations

- Use 2D wireframe section(s) to generate a 3D solid.
- This includes operations such as:
  - extrude
  - revolve
  - sweep
  - loft

From K. Lee “Principles of CAD/CAM/CAE Systems,” Addison-Wesley
Surface Operations

- These operate directly on the solid model faces, edges and vertices to create a desired modification.
- Examples:
  - chamfering
  - rounding/filleting
  - shelling

From K. Lee “Principles of CAD/CAM/CAE Systems,” Addison-Wesley
Transformation Operations

- These operations move and change face surfaces, edge curves, and vertex points.
- These operations also operate directly on the solid model faces, edges and vertices, but do not add or remove faces and edges.
- Examples:
  - Translate, Rotate, Scale
  - Draft (taper)
  - Move face, Dome
  - Flex: Bend, twist, stretch
- Although these operations do not seem like they would be ones that would appear in the Feature Manager, they are actually performed in sequence, like any other operation, due to limitations in parametric modeling.
Feature-Based Modeling

• “Features” (or “Engineering Features”) are shapes having engineering significance. They usually are the geometric embodiment of machining operations or the function of a component.

• They often are a collection of regular solid modeling operations that only exposes the important parameters.
Feature-Based Modeling

• Examples:
  – hole - pocket
  – slot - boss

• Many systems provide for user-defined features.

• Many people use the term “Feature” to refer to any kind of solid modeling operation.

From K. Lee “Principles of CAD/CAM/CAE Systems,” Addison-Wesley
Parametric Modeling

• Parameters are found in a CAD model as:
  – *dimensions* in 2D sketches
  – *dimensions* on 3D geometry (advanced systems only)
  – *modeling operation* parameters
  – *variables* in user-equations

• Entire part geometry can be controlled by a small number of key parameters!