Solid Modeling Techniques

Sweep Representation
Analytical Solid Modeling (ASM)

• Two and a half dimensional objects: The following two categories of solids are considered of this kind.
  • Solid of uniform thickness – Extruded solid
  • Axisymmetric solids – Solids of revolution
• The first kind is called Linear Sweep and the second kind is called rotational sweep
• Sweeping is used to create objects for B-rep and CSG representations. Thus it becomes an input option in many types of representations.
• There is no modeler entirely based on sweeping for the following reasons:
  • Limited domain
  • No formal theory
  • Validation and regularisation schemes are unknown
Types of Sweep Representation

<table>
<thead>
<tr>
<th>Closed Profile</th>
<th>Path</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Linear</td>
<td>Linear or circular</td>
</tr>
<tr>
<td>2. Nonlinear</td>
<td>Higher order curves</td>
</tr>
<tr>
<td>3. Hybrid</td>
<td>(1)(OP)(2) set operations</td>
</tr>
</tbody>
</table>

- Linear Sweep
- Circular sweep
- Nonlinear Sweep
- Hybrid Sweep
- Invalid Sweep
Basic Elements

**Primitives:** All 2-D contours are valid primitives. Lines, arcs, circles and B-splines are widely used.

The contour can be nested up to one level.

**Building Operations:** Generate the contour (profile) and a path curve (directrix). Sweep the profile along the path curve.

Analytical Solid Modeling (ASM)

- The method has its origin in FEM. The ASM follows similar approach as three dimensional isoparametric formulation in FEM.

  E.g. 8 noded hexahedron or 20 noded hexahedron

- ASM is mainly for design applications and not suited for manufacturing.

- It does not involve orientable surfaces as in B-rep and CSG

- **Applications:**
  1. Mass property calculation
  2. Composite material modeling
  3. Computer Animation
  4. FEM mesh generation with hyperpatch concepts.

  E.g. PATRAN-G is based on ASM and has interface to various FEA packages.
Basic Representation

ASM is an extension of bi-parametric surface representation to three-dimensional parametric space. Tensor product method is used as used in the case of surfaces. One can think of ASM solids as tricubic, Bezier and B-spline solids analogous to bicubic, Bezier and B-spline surfaces in 2-D parametric space \((u,v)\) and analogous to corresponding types of curves in one-dimension \((t)\).

![Diagram of Basic Representation](image)

Parametric Solids

Hyperpatch: The parametric solid is called hyperpatch as it is extension of and bounded by surface patches. The points in the interior and on the boundary of the parametric solid is given by

\[
P(u, v, w) = [x \ y \ z] = [x(u, v, w) \ y(u, v, w) \ z(u, v, w)]
\]

\[
u_{\text{min}} \leq u \leq u_{\text{max}}; \ v_{\text{min}} \leq v \leq v_{\text{max}}; \ w_{\text{min}} \leq w \leq w_{\text{max}}
\]

![Diagram of Parametric Solids](image)
Cubic Hyperpatch

**Building Operation:** The object is divided into hyperpatches. The hyperpatches are represented using surfaces and curves.

A cubic polynomial in each parameter is sufficient for most practical applications.

\[ P(u, v, w) = \sum_{i=1}^{4} \sum_{j=1}^{4} \sum_{k=1}^{4} C_{ijk} u^{i-1} v^{j-1} w^{k-1} \quad 0 \leq u \leq 1; 0 \leq v \leq 1; 0 \leq w \leq 1 \]