Istanbul Technical University – Faculty of Mechanical Engineering

CRN 11860 MAK422E Engineering Design and CAD Final Exam, Jan. 15, 2008

Instructor: Hikmet KOCABAŞ Time: 100 minutes

1. **(10)** Why in CAD/CAM/CAE the parametric representation is preferred?
Explain the advantage of parametric modeling approach where the part shape is specified by geometric constraints or dimensional relations.

Designer can modify the shape by changing the parameters associated with the geometric constraints or the dimensional relations and thus generates many design alternatives.

2. **(10)** What are the differences between Hermite, Bezier and Spline curves?

Hermite curve is defined two end points (P_1 , P_2) and two tangents at the ends (P_1' , P_2'). Curve degree is limited to 3.

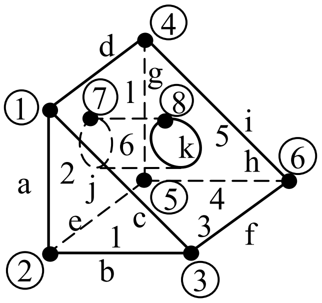
Bezier curve uses control points for approximate form, or points on curve for interpolate form. Curve degree is (n-1), where n is the number of points.

Spline curve is the same of Bezier, except curve degree is defined by user.

3. **(10)** What are the pros and cons (advantages and disadvantages) of boundary representation (B-Rep) data structure?

• This still bears a remote resemblance to Surface Modelling.
• Major differences are that,
  - inside/outside is defined for each surface
  - the edges, and vertices of touching faces are defined
• Advantages,
  - can store very complex geometries
  - easy to propagate changes to faces, edges and vertices
  - can easily generate and store complex surfaces
  - many systems support this method, such as PARASOLIDS, ACIS, etc.
  - can be used to mimic CSG
• Disadvantages,
  - high Level information is still not present in model
  - requires a powerful computer
  - hard to recognize some simple features like a block

4. (20) Check the validity of box in figure by using Euler-Poincare equation: F-E+V-L=2(B-G). How does a winged-edge data structure save the following solid model? Fill in the table by using sample data structure. 6–12+8–2 = 2(1–1) = 0



Edge	Vertices		Faces		Left Traverse		Right Traverse	
Name	Start	End	Left	Right	Pred	Succ	Pred	Succ
a	1	2	1	2	c	b	e	d
b	2	3	1	3	a	c	f	e
c	3	1	1	4	b	a	d	f
d	1	4	2	4	a	g	i	c
e	2	5	3	2	b	h	g	a
f	3	6	4	3	c	i	h	b
g	4	5	2	5	d	e	h	i
h	5	6	3	5	e	f	i	g
i	6	4	4	5	f	d	g	h
j	7	7	2	6	l	l	l	l
k	8	8	4	6	l	l	l	l
l	7	8	6	6	j	k	k	j

5. (10) What is the main advantage of modeling an object using manufacturing features in a feature based modeling system?

With the information on the existence, the size, and the location of the manufacturing features, process plan can be generated from the model directly.

Features are specific geometrical shapes on a part that can be associated with certain fabrication processes.
Features can be classified as form (geometric elements), material, precision (tolerancing data), and technological (performance characteristics).

The primary objectives of design by features:
Increase the efficiency of the designer during the geometric-modeling phase, and
Provide a bridge (mapping) to engineering-analysis and process-planning phases of product development. With the information on the existence, the size, and the location of the manufacturing features, process plan can be generated from the model directly.
A solid model is configured through a sequence of form-feature attachments to the primary representation of the part.
Features could be chosen from a library of pre-defined features or could be extracted from the solid models of earlier designs.
• Parts modelled by adding features to a base part
• Features represent manufacturing "operations"
- holes, ribs, fillets, chamfers, slots, pockets, etc.
• Material can be added or subtracted, similar to CSG
• Features are not limited to simple primitives, and can be created by extrusion, sweeping, revolving, etc.
• A history tree is created, similar to a CSG boolean tree

• The designer would simply define a part in terms of fundamental manufacturing features, such as chamfers, through slots, blind slots, etc.

• Very high level, but can complicate additions of unanticipated features, like a ridge in a car hood.

• Advantages,

  - very intuitive and easy to use
  - can simplify other aspects of CIM (eg. If a standard feature is used there will be a standard process plan to make that feature).
  - emphasizes the use of standard components.

• Disadvantages,

  - restrictive when dealing with nonstandard features
  - interaction of features can be hard to estimate
  - a complete set of all possible features would be very large

• There are two levels of features commonly used in these systems,

  - micro
  - macro

• A set of standard features for rotational parts might be,

  • Macro Features,
    - cylinder
    - taper
  • External Features
    - rotational fillet
    - thread
    - square neck
    - chamfer
    - shoulder
    - external radius
    - key seat
    - spline
    - flat
    - thread
  • Internal Features
    - internal taper

- internal slot
- internal tapered radial slot
- internal round slot
- countersink
- internal spline
- woodruff keyseat

• A set of prismatic features might be,

• Macro Features,

- box

• External Features

- linear chamfer
- linear round
- linear v slot
- linear slot
- linear round slot
- linear t-slot

• Internal features

- rectangular pocket
- linear fillet

6. (15) What are Design For X (DFX) acronyms?

DFA Design For Assembly

DFD Design For Disassembly

DFEMC Design For ElectroMagnetic Compatibility

DFESD Design For Electrostatic Discharge

DFI Design For Installability

DFM Design For Maintainability

DFM Design For Manufacturability

DFML Design For Material Logistics

DFP Design For Portability (Software)

DFQ Design For Quality

DFR Design For Redesign

DFR Design For Reliability

DFR Design For Reuse

DFS Design For Safety

DFS Design For Simplicity

DFS Design For Speed

DFT Design For Test

7. (15) Write down the main principles of Design for Assembly.

These techniques attempt to simplify products to ease the assembly process, without compromising functionality of the product.

Design rule summary

- Part Design
  1. Eliminate/minimize tangling between parts in feeders.
  2. Use symmetry to reduce the orientation time during handling
  3. If symmetry is not possible, use obvious features to speed orientation
- Product Design
  1. Reduce the number of parts when possible
  2. Build the part in layers from the top on the bottom, using gravity to locate parts
  3. Have the already assembled product stable on the work surface
  4. Have the work lie in a horizontal plane
  5. Use chamfers and fillets to ease mating of parts.
  6. Use snap-fits, and other quick fasteners, avoid screws, glue, etc.

The basic strategies of DFA for automated assembly are,

1. Reduce the number of parts
2. Allow assembly from the top of a fixtured part
3. Develop symmetry for easy part orientation
4. Use guides to simplify part mating, such as chamfers
5. Aim for snap-fit connectors, avoid screws
6. Reduce handling problems

- The basic rules of DFA for manual assembly are,
  1. the number of parts should be reduced
  2. parts should be standardized where possible
  3. alignment operations should be reduced
  4. locating and aligning features should be used
  5. allow clear paths for parts being added to the assembly
  6. add orientation features so that parts can only be assembled in the correct orientations
  7. consider part feeding/picking from batches
  8. introduce symmetries to reduce the need for reorientation
  9. add orientation features to simplify orientation identification

8. (10) How do you define a design optimization problem?

A design optimization problem requires to define:

- Design Variables (parametric design, dimensions, material properties, restraints)
- Object function
- Maximization or minimization of object function
- Constraints (stress, strain, dimension limits)