Written examination in

PPU080 – Advanced Computer Aided Design

Date: 2014-10-31, 8.30 – 12:30

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Department: Product and Production Development

Solution to the exam: On the course home page the day after the exam.
Preliminary results: On the course home page before 2014-11-20

Inspection of your exam result (at Lars Lindkvists office):

- 2014-11-24, 12.00-13.00
- 2014-11-26, 12.00-13.00

Aids

A Chalmers-approved calculator is permitted.

The examination contains 5 tasks, each worth 10 points.
Grades:

< 20 points: Fail
20-29 points: Grade 3
30-39 points: Grade 4
40-50 points: Grade 5

Do not treat more than one task on each page.

1. Geometry modeling

a) Describe the following three types of solid models, mention some advantages or disadvantages for each (6p)
   - Decomposition models
   - Constructive models
   - Boundary representation

b) Curves used in geometry modeling can be of different order. What are the advantages and disadvantages of higher order curves? (2p)

c) What is a digital mockup (DMU) and for what is it used? (2p)

Answers

a)

Decomposition models:

- Can be made of:
  - Voxels: the solid is composed of a number of cubes
  - Cell based: the solid is built up by polygons
- It is an approximate model and requires a lot of memory for high precision.
- It is suitable for different types of calculations

Constructive models:

- Solid models are created by manipulating primitives with Boolean operators.
- It is hard to handle general surfaces
- It is very compact (do not require a lot of memory)

Boundary representation:

- The solid is defined with points, curves and surfaces plus a definition of what is inside the model
- Uses graphical methods e.g. sweep and rotate
- Can use parametric surfaces
- Can use Boolean methods

b)

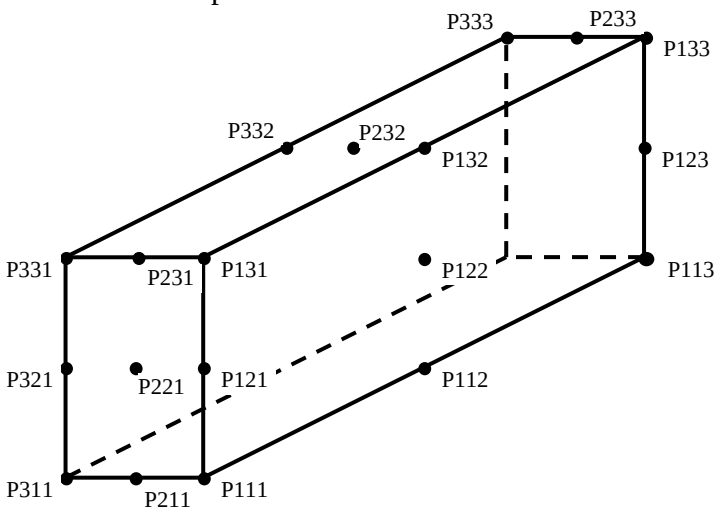
- Advantage: increased precision
- Disadvantages: risk for corrupt curves, increased calculation time

c)

- A special type of component based assembly model developed to be able handle large assemblies (> 1000 parts) from different CAD-systems
- Can be used for e.g. packaging studies and assembly simulation but not for e.g. calculation of mass etc.

2. Geometry assurance

a) Describe how a 3-2-1 locating scheme works (4p)
b) Define a 3-2-1 locating scheme for the box in the figure (6p)
- Use the points in the figure (P111-P333, located on the three visible surfaces)
- Try to make it as robust as possible
- **Motivate** your selection of points



Answers

a)
- Six DOF are locked by six points
- Primary points A1, A2 and A3 defines a plane and locks the geometry in space in two rotations and one translation: TZ, RX, RY
- Secondary points, B1 and B2, defines a line and locks the geometry in space in one rotation and one translation: TY, RZ
- Tetriary point C1 locks the geometry in space in one translation: TX

b)
A number of different solutions with almost the same robustness exist. This is one solution.
- Primary points A1, A2 and A3:
  - Points: P131, P133 and P112
  - This maximizes the area of the triangle defined by the points
  - Also e.g. P131, P133 and P113 would give the same area but in that case the corner P111 will be less robust
- Secondary points B1 and B2
  - Points P231 and P233
  - This maximizes the length of the line defined by the two points
  - (Also other selections gives the same length but this is the optimal one)
- Tertiary point C1
  - Point P221
  - (Any point on the same surface is OK but this is the optimal one)

3. Computer graphics and virtual reality

a) Describe the RGB color model (2p)
b) Describe (with text, figures and equations) the four steps for collision detection between two objects defined by triangle surfaces (6p)
c) Bump-mapping is a way of using textures to give a smooth surface an irregular appearance. Describe how it works. (2p)

Answers

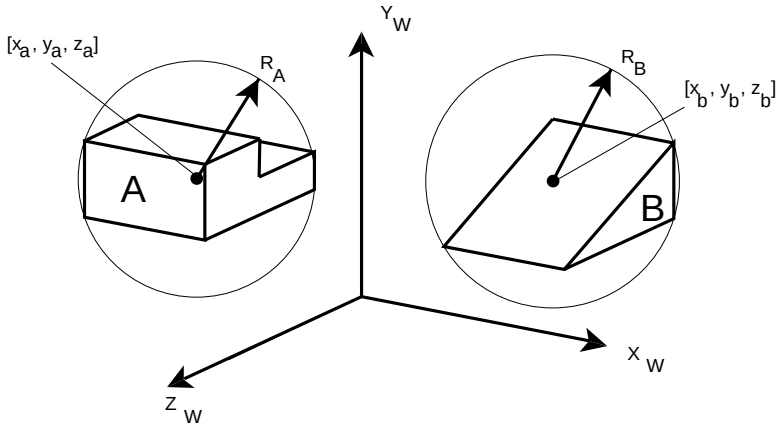
a)

The color is accomplished with a mixture of three primary colors

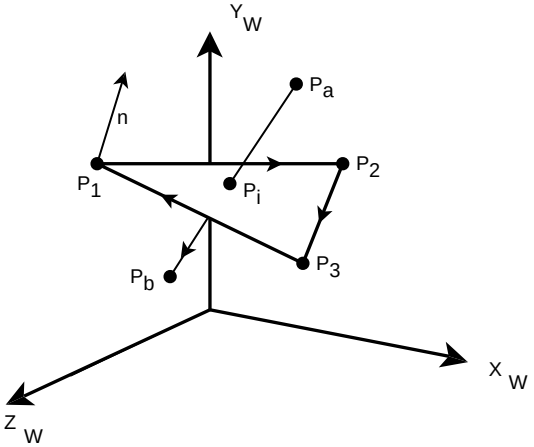
- Red [0 – 1] (or [0 – 255])
- Green [0 – 1]
- Blue [0 – 1]

b)

- Do a (fast) coarse ”Mini-max-test” with Bounding Boxes/Spheres to determine if a collision might be possible at all



- If yes, check if any of the points on body A is inside body

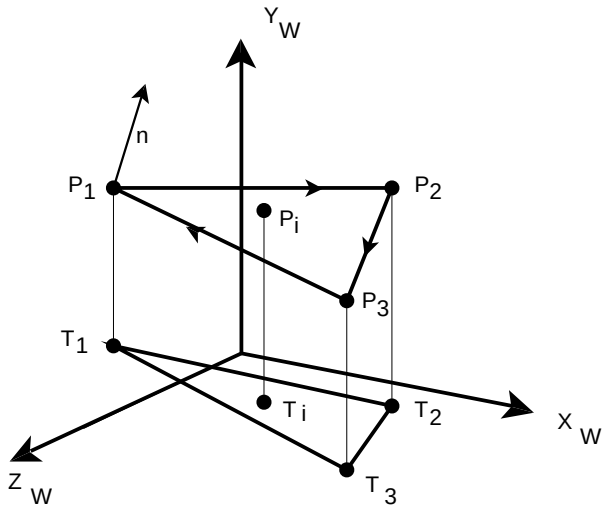


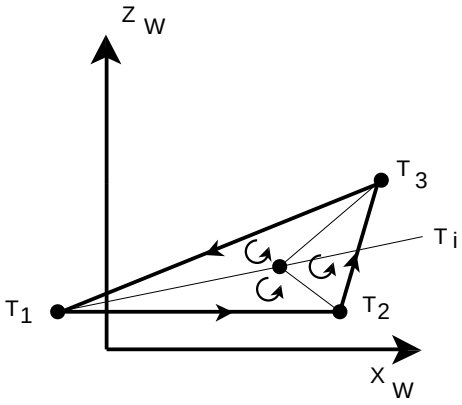
B

  - Test if any of the edges on body A intersects an infinite plane defined by some of the polygons on body B:
    - Test if the endpoints of the edge are on different sides of the plane. This is done by using the equation of the plane

  - If yes, calculate the intersection point between the edge and the plane:

        - Use the equation for the line between the points and the equation of the plane.
    - Check if the intersection point is on the polygon:





        - Calculate the area of the three sub triangles defined by the intersection point and the original vertices of the triangle.
        - If all these areas have the same sign, the intersection point is inside the triangle and it is a collision.
        - To speed up the calculation this can be done in 2D by projecting the triangle on a plane.

c)

- It works by modifying the surface normal that is used in the illumination model.
- The value of the modification is obtained from a texture.
- The color (RGB value) of each pixel indicates the surface normal modification.

4. Miscellaneous

a) Give two reasons for using ergonomic simulations with computer manikins. (2p)
b) Mention four different standards for geometry exchange and what type of geometry data they can handle. (4p)
c) Describe the concepts of *Component based* and *Feature based* assembly modeling (2p)
d) Mention two advantages of using off-line programming (2p)

Answers

a)

- Evaluation of user interfaces
- Evaluation of concept for manual assembly

b)
(four of)

- IGES
  - Mathematical description
- STL
  - Triangulated format
- VRML
  - Triangulated format
- JT
  - Both mathematical and triangulated
- STEP
  - Mathematical description

c)
Component based assembly modeling:

- The position of the part in the assembly is determined by specifying its position and orientation in global or relative coordinates

Feature based assembly modeling:

- Associates form features on different parts
- handles restrictions on form, position, orientation etc between mating form features

d)

- Avoid costly mistakes with real machines
- Faster and more efficient programming
- Possibility to make new programs without stopping the production

5. PLM/PDM

a) Mention three reasons for the increased industrial need for IT support for product development (3p)
b) How can PLM systems support an Engineering Change Management process? (4p)
c) Describe two different types of Bill of Material that are used in PLM systems. (3p)

Answers

a)

- Shorter lead-times and product lifecycles
- Increased complexity: variants, functions, components etc.
- Collaborative product development

b)

Automation, e.g.:

- Workflow functions automate information transfer
- Standard templates for change documents
- Parameterized CAD/CAM/CAE models

Monitoring, e.g.:

- Follow-up of engineering changes status
- Overview of all engineering changes

Information access & retrieval, e.g.:

- All have access to engineering changes in PDM database
- All info and doc's related to an engineering change is connected

Quality assurance, e.g.:

- Only authorized individuals may promote change requests
- Control of versions, status and effectivity

Review, e.g.:

- Check change history, rollback possible

c)

The engineering Bill of material (E-BOM)

- Organizing the various components of a product including software

Manufacturing Bill of Material (M-BOM)

- Structured according to the way a product is sourced and manufactured.
- Primarily supports supply chain including manufacturing