Written examination in

PPU080 – Advanced Computer Aided Design

Date: 2013-10-22, 14:00 – 18:00

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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 2012-11-09

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

- 2012-11-12, 12.00-13.00
- 2012-11-14, 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 steps necessary to create a solid, using surface modeling, in a modern CAD system. (5p)
b) Describe how trimmed parametric surfaces are defined/created (3p)
c) Bézier and B-spline are two types of curves used in geometry modeling. What is the advantage of B-spline curves? (2p)

Answers

a)

- Create wireframe elements (points, lines, planes, curves) in 3D or sketches
- Create surfaces from the wireframe geometries (sweep, revolve, ...)
- Trim the surfaces together
- Join the surfaces together to a uniform element
- Transform into a solid (Thick, Closed Surface, ...)
- (Add fillets)

b)

- Parametric surfaces are defined in a similar way as parametric curves but with two parameters u and v.
- Parametric curves are defined in the same 2D parametric space.
    - They are used to create holes (inner trim curves)
    - Or the outer boundary of the surface (outer trim curve)
- The trimmed parametric surface is transformed to 3D space

c)

- Better local control of the curve
- Order of the polynomial does not increase with the number of control points
- Easier to define joined curve segments

2. Geometry assurance

Variation analysis (with Monte Carlo simulation), Contribution analysis and Stability analysis are three different types of analyses used in CAT (Computer Aided Tolerancing) software. Describe how these methods work and what they are used for.

Answers

Variation analysis (with MC)

- Calculates a statistical prediction of the variation in critical measures
- Statistical method – random data
- Tolerances on parts (inputs) are randomly generated within defined distributions, tolerances and Cp
- Distributions for critical measures (outputs) are generated from thousands of iterations
- All kinematical relations and sensitivities are captured in a 3D assembly model

Contribution analysis

- Calculates a ranked list of how all input tolerances contributes to the variation in the critical measures
- All input parameters are varied (one at the time) within their tolerances on 3 levels
- Max output is registered
- Contribution is calculated in percent as $\% \, contribution_i = 100 \frac{\Delta output_i^2}{\sum_{i=1}^{n} \Delta output^2}$

Stability analysis

- Can be used to analyze the influence of each part locating scheme on
  - Variation amplification, color-coding
  - Position stability of parts
  - Critical product dimensions (Measures)
- It is done by disturbing each locating point with a unit disturbance
- And summarizing their contribution with RSS
- Is often used to evaluate different positioning systems

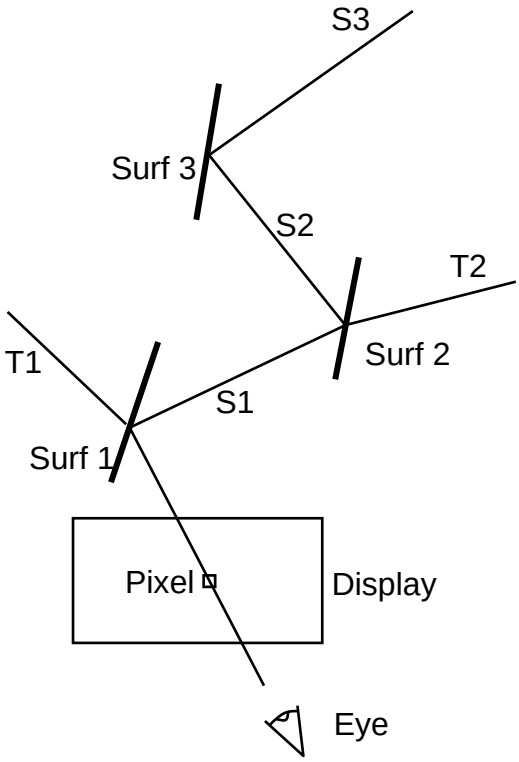
3. Computer graphics and virtual reality

Ray-Tracing and Radiosity are two different methods for advanced 3D computer graphics rendering.

a) Describe how these methods work. (4p)
b) Mention two advantages and two disadvantages of each of the two methods. (2p)
c) Three different types of coordinate systems are used in virtual reality models (and also in CAD models). Specify these and what they are used for. (4p)

Answers

a)



Ray-tracing

- Follow light rays from the observer, one for each pixel
- Calculate how the ray is mirrored and refracted (if the object is transparent) when it hits surfaces in the model, and save the way in a tree graph
- Calculate the intensity at the initial points with illumination models
- Use the tree to calculate the intensities at each pixel
- Handles automatically shadows, hidden surfaces and clipping

Radiosity

- Based on the effect that light sources and surfaces are emitting light
- Is done by iterating the emission of light
- In the first step only surfaces with direct light are visible
- In the next step these surfaces emits light to other surfaces
- This is repeated until the result is satisfactory

b) (two each of)

Ray-tracing

- Advantages
  - Good at transparent objects
  - Handles specular reflection well
  - Good at point light sources

- Disadvantages
    - Unnaturally sharp shadows
    - Bad at diffuse reflection
    - Not good at global light sources
    - Slow

Radiosity

- Advantages
    - Good at diffuse reflection
    - Gives realistic shadows
    - Good at global light sources
- Disadvantages
    - Not good at specular reflection
    - Not good for transparent objects
    - Not good at point light sources
    - Slow

c)

1. World coordinate system (w)
    - Only one in each model
    - The position of other objects are related to this
2. Object coordinate system (o)
    - One coordinate system per object in the model
    - Positions the object relative to the world coordinate system or relative to a superseding object
3. The coordinate system of the observer (Virtual Observer)
    - Makes it possible to travel around in the model

4. Miscellaneous

a) What are the industrial benefits of using parameterization to reuse engineering knowledge? (2p)
b) The Method of Influence Coefficients can be used to perform Monte Carlo variation simulations on non-rigid parts. How does it work? (5p)
c) Mention three reasons for the increased industrial need for IT support for product development (3p)

Answers

a)
Shorter time – means more iterations, i.e. more design solutions can be evaluated.
More iterations means better products because:

- Larger amount of designs considered and evaluated in concept phase
- Knowledge related to lifecycle aspects (design for: assembly, manufacturing, serviceability, environment…) can be integrated in detail design phase
- Synthesis – analysis loops can be shortened – verification feedback instant

b)

- When doing a Monte Carlo variation simulation more than 1000 iterations have to be done
- To do this with traditional FE methods would take too long time
- Therefore, a FE solver is used to create a linearized model of the assembly
- The linearized model is then used in the simulations
- This gives a very large reduction of the simulation time (~ a factor 1000)
- If the locators or support points are moved, a new linearization has to be done

c)

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

5. PLM/PDM

a) Mention the five basic needs of engineering information management. (5p)
b) Describe two different types of Bill of Material that are used in PLM systems. (3p)
c) Mention two important tasks for a PLM systems functions for version control. (2p)

Answers

a)

- Capture information at the source
- Organize information
- Distribute the information – when, where, what, to whom
- Search, re-use and present information
- Secure storage of information over a long time

b)

1. The engineering Bill of material (E-BOM)
    - Organizing the various components of a product including software
2. Manufacturing Bill of Material (M-BOM)
    - Structured according to the way a product is sourced and manufactured.
    - Primarily supports supply chain including manufacturing

c)

- Keep track of all versions of a specific piece of information
- Pick up the currently valid version as well as at given earlier dates – the information's history