Delft University of Technology
Faculty of Electrical Engineering, Mathematics,
and Computer Science

TU Delft

Examination for

IN4086 Data Visualization

Wednesday April 6, 2011, 14:00 – 17:00 h.

This examination has 6 open questions on 2 pages.
All questions have equal weight (10 points/question). Maximum score = 60 points.
Minimum score required for passing the exam: 33 points.

Use of notes, books and readers is *not* permitted;
The use of (graphical) calculators is permitted.

Write and draw clearly. Avoid verbose explanations; answers in the form of bulleted lists are preferred. Explain all your answers.

Please use a separate sheet for each question.
Write on each sheet: your name, study number, course code (IN4086), date, and question number. This is important because each question is graded separately.

The examination covers the following materials:
Course sheets fall 2010, Reader IN4086, edition 2009 or 2010.

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1. a. The three standard mappings for visualization of a 2D scalar field are: *colour mapping, height fields,* and *contour plots*. Briefly describe the meaning of these mappings, and define for each mapping the precise relation between data values and visual parameters. *(3)*

   b. Describe a way to generate a contour plot of a 2D scalar field using only a colour scale, without further computations. *(3)*

   c. Four data points P_1 ... P_4 are the corner points of a 2D rectangular grid cell. The data values at $P_1 \ldots P_4$ are $d_1 \ldots d_4$ respectively. Inside the cell lies an arbitrary point $P(\alpha,\beta)$ with: $\alpha,\beta \in [0 \ldots 1]$, and data value d_P. Derive the expression for determining d_P by bi-linear interpolation. *(4)*

2. a. Volume data can be interpreted as *voxels* or as *cells*. Describe the essential difference between these two interpretations. *(3)*

   b. How can most easily be decided in *volume slicing* whether a cell is intersected by the slice $ax + by + cz + d = 0$ or not? *(3)*

   c. In the *Marching Cubes algorithm* an index is mapped to one of 15 different cases. Three of these cases have 2 vertices classified as INSIDE and 6 vertices classified as OUTSIDE. Make a clear drawing of these three cases. Mark the INSIDE vertices in these drawings with a dot and draw the triangles in the cubes. Which is the ambiguous case? Only draw one set of triangles (the simplest one) for this ambiguous case. *(4)*

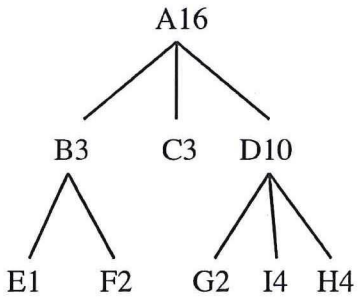
Continued on next page

3. a. Make a drawing of an example intensity profile in volume ray casting. Clearly explain the meaning of the horizontal axis and the vertical axis. How can a color be derived from the intensity profile with Maximum Intensity Projection? *(4)*
   b. Explain why in Volume Visualization voxels must be projected in front to back (FTB) or back to front (BTF) order instead of arbitrary order. *(3)*
   c. In the Shear Warp Factorization algorithm four transformations are applied: a projection, a shear, a warp and a permutation of axes. In which order must these four transformations be applied? For what reason is the permutation of axes necessary? *(3)*

4. a. What is a gradient image? What is the significance of the gradient magnitude? For which purpose can it be used? *(4)*
   b. The wall of the colon has many tissue folds, which makes it difficult to examine the complete inner surface during a virtual colonoscopy (parts are missed). Explain why this is a (medical) problem. Describe a (technical) solution to this problem: You have to correctly describe the solution and explain how it addresses the problem. *(3)*
   c. Explain image registration in the context of medical image processing and visualization. Give one or more applications of registration. *(3)*

5. a. What are *time lines* in a velocity field? How can time lines be determined using the particle path computation? How can this be extended to time surfaces? *(3)*
   b. In the integration step of the particle path calculation a *variable time step* can be used instead of a fixed time step. Why can this be an improvement? Describe a technique for adjusting the time step. *(3)*
   c. Define the concept of a *feature* as used in feature-based visualization. Give three examples of features in flow fields. *(4)*

6. a. What is a scatter plot? Which characteristics of a data set are represented best by a scatter plot? *(2)*



   b. In the figure above a hierarchical structure is shown as a tree diagram, in which the nodes are marked as capital letters, with an attached number (eg. file size). Show how this structure can also be visualized as a treemap. *(3)*
   c. Currently, many *autostereoscopic* displays or prints use *lenticular lenses*. Describe what autostereoscopy entails for the user viewing such a display, and explain (e.g. draw a simple illustration) how lenticular lenses can help to achieve a basic stereo effect. *(2)*
   d. In an interactive VR system, a *tracking* system can be used to measure the 3D position and orientation of the head and physical, hand-held tools. Describe the general process of head tracking, and what the effect is of head orientation/rotation in the case of (i) standing in front of a big projection screen or (ii) wearing a head-mounted display. Which of these two cases suffers most from high end-to-end latency? *(3)*

End of examination