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

TU Delft

Examination for

# IN4086 Data Visualization

Wednesday April 7, 2010, 14:00 – 17:00 h.

This examination has 6 open questions on 3 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 2009/2010, Reader IN4086, edition 2009/2010.

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1. a. Describe in general what happens in the *mapping* stage of the visualization pipeline process, and give at least one example. *(3)*

   b. Make a drawing of a 2D *non-uniform rectangular* grid. Give a representation of this type of grid that allows you to calculate the coordinates of an arbitrary grid point (i,j) relative to a base point (xp, yp), and clearly show how this calculation is excecuted. *(3)*

   c. To determine the local position of a point P inside a tetrahedron ABCD, we can use inverse interpolation. Given the global position of P, we can express the position of P as a function of the vertex positions ABCD of the tetrahedron, using the local coordinates $(\alpha,\beta,\gamma)$ of P $(0 \leq \alpha,\beta,\gamma \leq 1)$, with the formula:

   $$P = D + \alpha\,(A-D) + \beta\,(B-D) + \gamma\,(C-D)$$

   Using this formula, how can we calculate the local position $(\alpha,\beta,\gamma)$ of P? *(4)*

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2. a. Which condition must be true in order that an iso-curve intersects a cell in 2D scalar data? *(2)*
   b. Make a drawing of all possible cases of intersection of a cell with an iso-curve. Cases that can be created from each other by rotation or mirroring are not considered to be different. Which cases are ambiguous, i.e. in which cases can the cell be intersected by the iso-surface in two or more different ways? *(3)*
   c. In the Marching Cubes algorithm an index between 0 and 255 is found for a cell. Explain how this index is created. *(3)*
   d. How can the exact position of a triangle vertex be calculated in the Marching Cubes algorithm, when the cell edge on which this vertex must lie is already known? Give a formula for this calculation. *(2)*

3. a. Is *volume ray casting* an object order technique or an image order technique? Is *voxel projection* an object order technique or an image order technique? Clarify your answers with a short explanation of both the volume ray casting method and the voxel projection method. *(4)*
   b. Is shear warp factorization an object order technique or an image order technique? An explanation is not needed.

      The viewing transformation in shear warp factorization is the product of 3 transformations. Which transformations and in which order? *(3)*
   c. In volume ray casting an approximation of the ray casting integral is used: $I(N,X) = \sum_{i=0}^{n} C_i \alpha_i \prod_{j=i+1}^{n} (1-\alpha_j)$

      Is this the formula for front to back or for back to front ray casting? What is the meaning of N, X, n, $C_i$ and $\alpha_i$ in this formula? Give a short explanation which shows that this formula is feasible. *(3)*

4. a. Explain the basic principles of MRI. What is the main advantage of MRI over CT? Why is MRI not used in all cases instead of CT? *(4)*
   b. Explain the partial volume effect that often occurs in medical images: Define the effect, explain why and when it occurs and also how it manifests in the acquired data. You may use illustrations to facilitate your explanation. *(3)*
   c. In diffusion tensor imaging (DTI), MRI is used to visualize neural fiber bundles (connections) in the brain. What is DTI actually measuring? Why can we use this to visualize neural fibers? What medical application is DTI used for? *(3)*

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5. a. An arrow plot (hedgehog) is a simple technique for visualization of 3D vector fields. Discuss the advantages and limitations of this technique, and suggest improvements. *(3)*

   b. Can streamlines in a stationary velocity field generally intersect each other? Explain why they can or cannot. Is there an exception? *(4)*

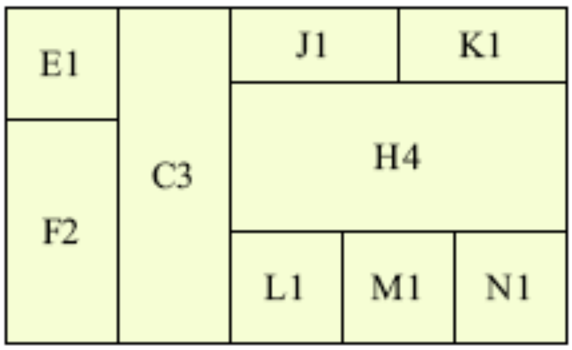
   c. In particle path computation, a first order (Euler) or a higher-order (Runge-Kutta) integration step can be applied. With first-order integration, certain inaccuracies will be apparent. Clearly show in a drawing the nature of these inaccuracies and explain why this is the case. How is this for second-order integration? *(3)*

6. a. A stereo display can provide the *binocular parallax* depth cue and is an important feature in VR systems. Explain how an *auto-stereoscopic* display achieves this effect. *(2)*

   b. In an interactive VR system a tracking system can be used to measure the position and orientation of the head and physical, hand-held tools. Explain how *co-located tracking* can be achieved in such a system. Why would this be more important on the Virtual Workbench than a (non see-through) Head-Mounted Display? *(3)*

   c. Briefly explain the concept of a magic lens and give an example of its use. *(2)*

   d. In the figure below a tree structure (such as a file hierarchy) is visualized with a *treemap*. Only the leaves of the tree are shown. The nodes are marked with a letter and a number representing the size of the object (eg. a file). Show in a drawing how this tree structure can be visualized as a *tree diagram*, and explain how the nodes at the higher levels are derived from the treemap. *(3)*




**End of examination**