Delft University of Technology
Faculty Electrical Engineering, Mathematics,
and Computer Science
Mekelweg 4, Delft

TU Delft

Examination for

Course IN4151 - 3D Computer Graphics and Virtual Reality

March 30, 2009, 14:00 – 17:00 h.

Please use a separate sheet for each question.

Write on **each sheet**: your name + initials, study number, course code (IN4151), date, and the question number. This is important because each question is graded separately.

Criteria for receiving the maximum grade per question are correctness and brevity of the answers.

Make sure your writing is legible and drawings are clear!

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1. a) For modelling and projective display of polygon models we apply several coordinate systems and transformations between these systems. Describe these coordinate systems and transformations.
   b) Derive the perspective foreshortening of x and y as a function of z and the distance d of the center of projection (eye point) and the image plane. Give the matrix for the perspective transformation.
   c) In VR with projective display an off-axis projection is used. What is meant with this kind of projection?

2. a) Describe the Phong reflectance model. Give its three main components and explain the parameters. How is colour represented?
   b) A more sophisticated reflectance model is the Cook–Torrance model. Describe the major improvements over the Phong model.
   c). The human skin requires an even more sophisticated model. What kind of effect should be modelled and how can this be done?

3. a. What kind of light paths are sampled by standard ray tracing?
   b. How can ray tracing be extended to include also other paths?
   c. Give two versions of a two-pass (ray tracing - radiosity) algorithm.

4. a. Describe the ray-box intersection algorithm.

   b. Describe the ray traversal for the hierarchical bounding box method, and the ray traversal algorithm for a voxel grid.

   c. What are the advantages and disadvantages of the hierarchical bounding box method compared to the regular grid method?

5. a) Describe environment mapping for simulating mirroring reflection.

   b) How can we extend the method to environment lighting for diffuse reflection?

   c) What is the principle of ambient occlusion? How can this be combined with environment lighting?

6. a. Name and describe two methods to calculate the position and orientation of all the links in articulated structure animation, so for instance the animation of a running human being or a running animal. What user (= animator) input is required for each of these methods? How many solutions are there for the positions and orientations of all links for each of these methods?

   b. L-systems can be (1) parametric, (2) stochastic and (3) context sensitive. Give an example rule for each of these 3 types of L-systems. Shortly explain the meaning of every rule.

   c. Rotations can be specified with quaternions. What is the quaternion q that represents a 3D rotation about the y-axis with 90 degrees? P = (2, 0, 0) is mapped on point P' when this rotation is applied. Calculate with quaternions the coordinates of point P'.

   Remark: You can easily verify your answer with a drawing or a matrix-vector multiplication. However, you will only get points for this question by writing down the calculation with quaternions.

end of examination