2IV10/2IV60 Computer Graphics

Intermediate Examination, December 16 2013, 10:45 – 12:30

This examination consist of **three** questions with in total 9 subquestion. Each subquestion weighs equally. In all cases: **EXPLAIN YOUR ANSWER. Use sketches where needed to clarify your answer. Read first all questions completely.** If an algorithm is asked, then a description in steps or pseudo-code is expected, which is clear enough to be easily transferred to real code. Aim at compactness and clarity. Use additional functions and procedures if desired. Give from each function and procedure a short description of input and output. The use of the book, copies of slides, notes and other material is not allowed.

1 We consider drawing a cylinder. Suppose that we have a basic function *DrawCyl* , which draws a cylinder defined by $x^2 + y^2 = 1$ and $0 \le z \le 1$: unit radius, unit height, and the axis of rotational symmetry is aligned with the z-axis. This cylinder is defined in a local coordinate frame, global positions X are derived from local coordinates X' by $X=MX'$, where M is a homogenous transformation matrix. Furthermore, suppose that we have a set of functions to define transformation matrices, *i.e.*,

- $T(V)$ gives a translation matrix over a vector V;
- $S(s_x, s_y, s_z)$ gives a scaling matrix with scale factors s_x, s_y, and s_z for the axes; and
- $R_k(a)$ gives a counterclockwise rotation over a radians around axis k (= x, y, or z).

We want to define a more generic function to draw a cylinder. The center of the bottom of the cylinder should be a point P; the center of the top of the cylinder should be a point Q; the cylinder should have radius r. We define this function in a few steps. For b) and c) results from earlier subquestions can be used.

a) First, define a matrix M_S such that setting $M = M_S$ gives a cylinder with the desired dimensions.

b) Next, define a matrix M_D such that the cylinder is drawn with the desired orientation and dimensions, but with the center of the bottom still at the origin. What is the angle α between the axis of the cylinder and the z-axis; what is the angle β between the projection of the axis of the cylinder on the XOY-plane and the X-axis? You can use these to define M_D such that setting $M = M_D$ gives the desired result.

c) Finally, define M such that a call to *DrawCyl* produces a cylinder from P to Q with radius r.

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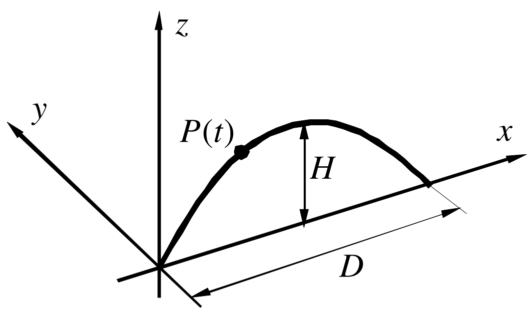
2 We consider making a movie of a human cannonball. The path $P(t)$ of the helmet of our volunteer is given by $P(t) = (30t, 0, 20t - 5t^2)$, where t is the time in seconds, and where $P_z(t) \ge 0$. We use two virtual cameras, one mounted on the helmet of the volunteer, and a fixed camera viewing the scene from the side. Both cameras are specified using an eye-point $E(t)$, a center-point $C(t)$, and a view-up vector $T(t)$. The view angle of the camera is 90 degrees, both horizontally as well as vertically. Answer the following questions.



a) Give the distance D that is travelled and the maximum height H.

b) Give $E(t)$, $C(t)$, and $T(t)$ for the helmet mounted camera. Assume that the camera moves and views along the path of the helmet.

c) Give E, C, and T for the fixed camera. Assume that a standard right-handed coordinate system is used. The camera is located on a tower, in such a position that the complete flight is visible and viewed as large as possible. Make sure that the volunteer flies from left to right on the view by the camera.

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3 We consider a surface patch defined by $z = yx^2$, with $0 \le x \le 1$ and $0 \le y \le 1$.

a) Give a parametric definition $P(u, v)$ with $0 \le u, v \le 1$ of this surface; and an implicit definition $f(x, y, z) = 0$ of the unbounded surface where this patch is part of.

b) Give a procedure to draw the surface patch, assuming a function $DT(A, B, C)$ is available to draw a triangle ABC. Use a parameter M for the number of segments that is used to approximate each side of the boundaries.

c) Give a unit normal N for an arbitrary point on this surface patch. Choose yourself if you assume the point to be given via coordinates (x, y, z) or parameter values (u, v).