2007/2008 Graphics Tutorial 7

Problem 1 *We have seen several methods for computing ray/triangle intersections.*

1. *Explain how we can do ray/object intersection tests in $\mathbb{R}^3$ with matrix operations.*
2. *The matrices from the previous question are 3×3 matrices. Suppose that we have an implementation of a 4×4 matrix class, that we want to use for ray/object intersection test. Howe do we do this, i.e., what do we do with the extraneous row and column?*

Problem 2 *If we look at* refraction*, then there is the case of* total internal reflection*. Suppose that a ray of light travels through air (with a refractive index close to one), hits a glass sphere (with refractive index higher than one, say, 1.46 for SiO_2), and refracts into the glass. Is it possible that this ray "gets caught" in the glass by total internal reflection?*

Problem 3 *Suppose we have an object O, a transformation matrix M, and a ray r. How do we compute the intersection p of r and MO? And how do we compute the normal n to the surface of MO in p?*

Problem 4 *Let C be an axis-parallel cube in $\mathbb{R}^3$ with center $(0, 0, 4)$ and edge lengths 2, let S be a sphere with radius 1.2 and center $(0, 0, 2)$, and let O be $C - S$. What is the intersection of the ray $(x, y, z) = t(0, 0, 1)$ with O? This example is rather "easy"; explain how you compute intersections of rays with CSG objects in general.*

Problem 5 *Suppose that we have a scene with n (small) objects, and a kd-tree for the scene (which is the particular type of BSP tree that we discussed in the lecture of Oct 25), such that the leaves of the tree contain at most three object. For simplicity, we assume that no object is split by the splitting planes of the kd-tree.*

1. *Explain how we can use the kd-tree to speed-up ray/object intersection tests.*
2. *Suppose that the tree is balanced. How much time do we spend at most to find the first object that is hit by a given ray, assuming that a single ray/object intersection test takes constant time?*

Problem 6 *For shadow feelers, we can speed-up the ray/object intersection test by cashing the object that was hit by the last shadow feeler. Why does this (possibly) improves performance, and why isn't his technique used for primary rays and recursively traced rays (the perfectly specularly reflected rays)?*

Problem 7 *Our texbook gives a function* stripe *that generates a stripe texture (see also the lecture notes on texture mapping). Adapt this function to generate a* tile *texture, giving square tiles any plane that is orthogonal to the X-, Y-, or Z-axis. The size of the square tiles must be controllable.*

Problem 8 *For planes that are not orthogonal to the X-, Y-, or Z-axis, the texturing function from the previous problem will create non-square (but rectangular) tiles. What can we do to create a square tile texture for such planes?*

Problem 9 *Explain what bilinear interpolation is (in the context of texture mapping), and explain why we would want to use it.*

Problem 10 *What is* mip-mapping*?*

Problem 11 *Explain the principles of* Perlin noise*.*

Problem 12 *How do we map a rectangular image (of, say, a map of the world in mercator projection) onto a sphere?*

Problem 13 *A 3D triangulated model can be represented by a* triangle soup *(i.e., a collection of individual triangles), or by a* triangle mesh *(in which case neighboring triangles share their common vertices). What is the advantage for texturing of the latter representation?*

Problem 14 *What is the relation between* bump mapping *and* displacement mapping*?*