CS 4620 Homework 3: Quads, Triangles and Tetrahedra

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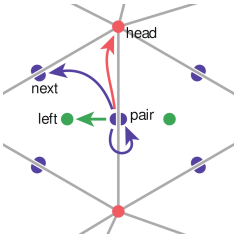
out: Friday 11 September 2009
due: Monday 21 September 2009

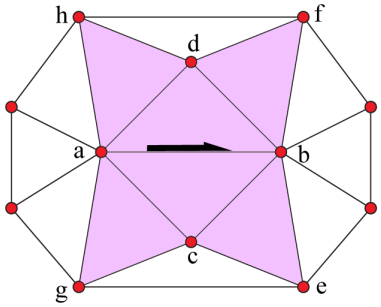
Problem 1: Ray-Quad Intersection (An exercise in thinking outside the triangle.)

Consider a planar, convex quadrilateral specified by a list of four 3D vertex positions, $(\mathbf{p_0}, \mathbf{p_1}, \mathbf{p_2}, \mathbf{p_3})$, and a ray $\mathbf{r}(t) = \mathbf{e} + t\mathbf{d}$, $t > 0$. In this question, you will devise an efficient method to test for ray-quad intersection, and determine any intersection point, $\mathbf{p}_{hit}$. First, read the "linear system approach" described in the textbook (§4.4.2) for ray-triangle intersection testing. Next, describe a modified method that works for planar, convex quadrilaterals. Provide mathematical reasoning, an illustrative figure, and a clear description of your algorithm.

Problem 2: Half-edge Handiwork (An→exercise→in→pointer→following)



Recall the half-edge data structure from class and Ch.12 (see inset image). In this question, we will use the notational convention that a half-edge h_{ij} points to vertex v_i (the head) from vertex v_j (the tail). Let the fields of the half-edge be accessed using the names shown in the figure: the next half-edge around the polygon is accessed via h_{ij}.`next`, the opposite half-edge is accessed via h_{ij}.`pair`, the half-edge's (left) face is accessed via h_{ij}.`left`, and its (head) vertex via h_{ij}.`head`.



Consider the mesh shown in the figure. Given the half-edge h_{ba}, give the pseudocode of pointer operations you would need to extract the vertex references for **a, b, c, d, e, f, g, h**. Instead of writing code, specify each vertex reference explicitly using the fields of h_{ba}. Your answer should be of the form:

a = h_{ba}.`pair.head`;
b = h_{ba}.`head`;
c = h_{ba}.??...
d = h_{ba}.??...
⋮
h = h_{ba}.??...

Note that you can not randomly access edges by name, e.g., h_{fb}, but rather must traverse the datastructure recursively from the h_{ba} reference. *(Tip: You might want to draw a picture with the half-edges shown to help yourself.)*

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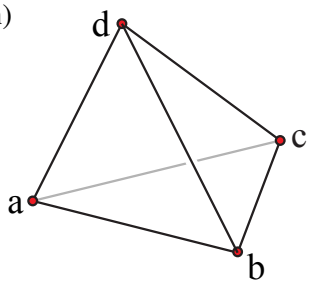
Problem 3: Surface Representation (Exploring your geometric diction)

Consider a tetrahedron consisting of the four vertices $\mathbf{a}$, $\mathbf{b}$, $\mathbf{c}$, $\mathbf{d}$ as shown in the figure.



1. Give an explicit (parametric) representation for the surface. *(Note: You can describe the surface piecewise.)*
2. Give an implicit representation for the surface, $f(\mathbf{x}) = 0$, by defining a suitable function, f.