

Ray Triangle Intersection

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Given a triangle defined by points p_0 , p_1 and p_2 and a ray given by its origin o and direction d , the barycentrics of the hit point as well as the t -value of the hit can be obtained by solving the system:

$$\begin{bmatrix} e_1 & e_2 & -d \end{bmatrix} \begin{bmatrix} u \\ v \\ t \end{bmatrix} = s$$

Where:

$$e_1 = p_1 - p_0$$

$$e_2 = p_2 - p_0$$

$$s = o - p_0$$

This system can be solved by Cramer's Rule, yielding:

$$\begin{bmatrix} u \\ v \\ t \end{bmatrix} = \frac{1}{\begin{vmatrix} e_1 & e_2 & -d \end{vmatrix}} \begin{bmatrix} \begin{vmatrix} s & e_2 & -d \end{vmatrix} \\ \begin{vmatrix} e_1 & s & -d \end{vmatrix} \\ \begin{vmatrix} e_1 & e_2 & s \end{vmatrix} \end{bmatrix}$$

In the above, $|a \ b \ c|$ denotes the determinant of the 3×3 with column vectors a, b, c .

Note that since the determinant is given by:

$$\begin{vmatrix} a & b & c \end{vmatrix} = (a \times b) \cdot c = (b \times c) \cdot a = (c \times a) \cdot b$$

, you can rewrite the above as:

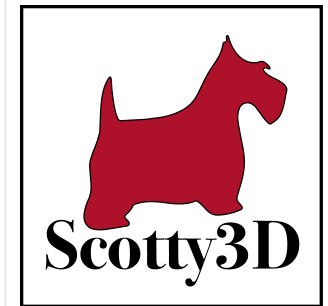
$$\begin{bmatrix} u \\ v \\ t \end{bmatrix} = \frac{1}{(e_1 \times d) \cdot e_2} \begin{bmatrix} -(s \times e_2) \cdot d \\ (e_1 \times d) \cdot s \\ -(s \times e_2) \cdot e_1 \end{bmatrix}$$

Of which you should notice a few common subexpressions that, if exploited in an implementation, make computation of t , u , and v substantially more efficient.

A few final notes and thoughts:

If the denominator $\text{dot}((e_1 \times d), e_2)$ is zero, what does that mean about the relationship of the ray and the triangle? Can a triangle with this area be hit by a ray? Given u and v , how do you know if the ray hits the triangle? Don't forget that the intersection point on the ray should be within the ray's min_t and max_t bounds.

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