

LA-UR- 00-1065

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**research note**

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Symbol: X-6:00-??? (U)  
Date: February 25, 2000

**Subject: Monte Carlo Particle Transport on a General Hexahedral Mesh**

**Executive Summary**

We are interested in tracking Monte Carlo particles on a general, hexahedral mesh whose cell faces are bilinear surfaces. We derive the solution for intersecting a ray with a parameterized bilinear surface comprised of four (non-coplanar) nodes. The matrix is nonlinear in the two parameters of the bilinear surface, but can nevertheless be solved analytically. We discuss the algorithm for tracking in a general hexahedral mesh and some ways to speed up the process. We also discuss sampling a position on a bilinear face and in a general hexahedral volume.

**1. Introduction**

We are looking to extend the mesh tracking capabilities of MILAGRO [1], a 3-D Implicit Monte Carlo (IMC) code for thermal radiative transfer, beyond its current orthogonal, structured mesh capability to a node based, unstructured, hexahedral mesh. There are many ways for us to track on this mesh given that data are stored on the nodes. Since the transport in MILAGRO is based on cell-centered quantities, one option is to track on node-centered cells constructed from pieces of all the original cells about the node. Unfortunately, although each node-centered cell would have constant data, each node-centered cell could be an ugly, non-convex, 24-sided cell. We could also track on a sub-mesh—on what amounts to the corners of the original mesh cells—which would be defined by the cell-centers and face-centers of the original cells. These corner cells will still be hexahedral like the original cells and there will be eight times as many of them, but we can assume constant data within the cell. A more advanced possibility is to perform the source and tallies using the eight basis functions within each cell. We opt to start with the most straightforward approach: to track on the original hexahedral mesh, where the data are homogenized over the cell.

Tracking on a hexahedral mesh requires sampling positions on a bilinear face, sampling positions in a trilinear volume, and calculating the distance from a particle to a bilinear surface along the particle's path. We present the equations for the bilinear surface and solve for a ray's intersection distance and surface point. The resulting matrix equation is nonlinear in the two bilinear parameters, but can be solved analytically. We conclude by discussing how to sample positions in a general hexahedral mesh.

