SAND2019-7905D

iSAFE
Interns for Security, Arms control and Force protection Engineering

Implementation of CAD models in GADRAS

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Implementation of CAD model analysis in GADRAS is performed by using STL files to approximate solid models. These STL files are then ray traced using an octree data structure to eliminate unnecessary ray-polygon intersection tests. Voxelization of source volumes is then performed by creating a tetrahedral mesh and subdividing tetrahedron based on the three dimensions framework of GADRAS's adaptive mesher.

What is GADRAS?

Gamma Detector Response and Analysis Software, or GADRAS, is a software suite capable of modeling response signals from gamma-ray and neutron detectors. GADRAS is capable of displaying measured or computed spectra, characterizing detectors and analyzing spectra to identify isotopes and estimate flux profiles. These capabilities are performed in a matter of minutes and provide users with accurate data quickly.

Figure 1: GADRAS Logo

How it works

In order to solve the transport problem quickly, GADRAS reduces complex sources into small, discrete volumes called voxels. These voxels are subdivided until they can be considered a point source in the scope of the problem. The goal is to minimize the importance gradient across each voxel such that the integration error across each is also minimized. Rays are then draw from the voxels to the detector to determine what materials are passed through for what distance. GADRAS is then able to determine the detector response based on each individual ray, aggregate all of the solutions, and determine the detector response as a whole.

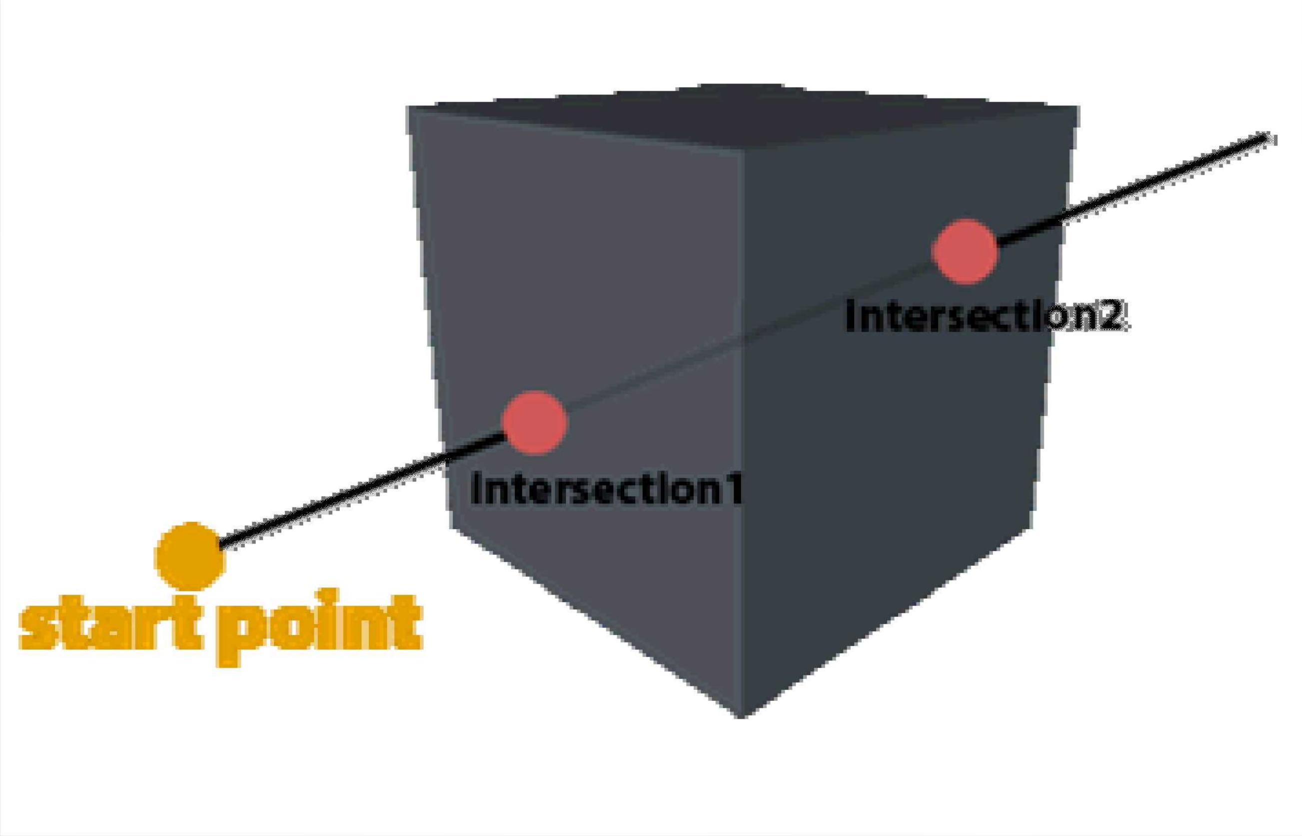

Figure 2: Ray Tracing example (Developers.maxon.net, 2019)

Why it's a problem

Currently, GADRAS is only capable of six shape primitives: spheres, sphe boxes, cylinders, round-end cylin cones. These primitives can then together to create more complicate however, this process uses large nu primitives, approximates certain g and creates inflexible models complications create the need for ar import CAD models directly into G analysis. For this application, STL chosen as a generic method for model representation.

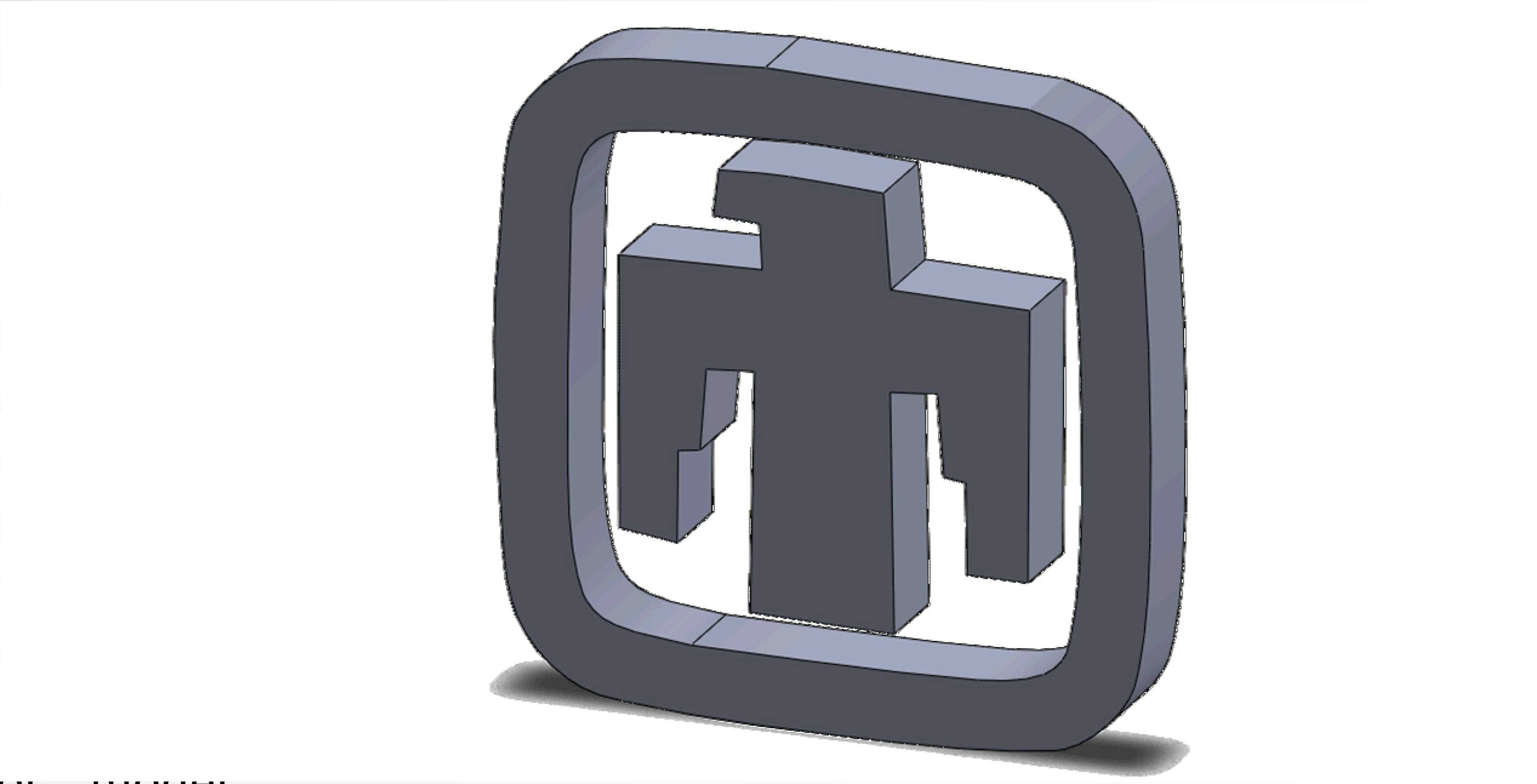

Figure 3: Difficult to create model in GADRAS

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Ray Tracing STL Files

STL files are a collection of triangles and normals that approximate the surface of a model. These approximations can be on the order of 100,000 triangles and are not guaranteed to be convex for complex models. In order to find all intersections of a ray with a model represented by an STL file, every triangle must be analyzed. By creating an octree data structure to sort the triangles, the octree can be searched first to find only the intersected nodes, eliminating the need to search large groups of triangles. An octree is a spatial tree data structure that consists of cubic nodes that hold triangles that are wholly or partially contained in their volume. Each node can then be recursively divided into eight child nodes until a certain depth, or fill count is reached.

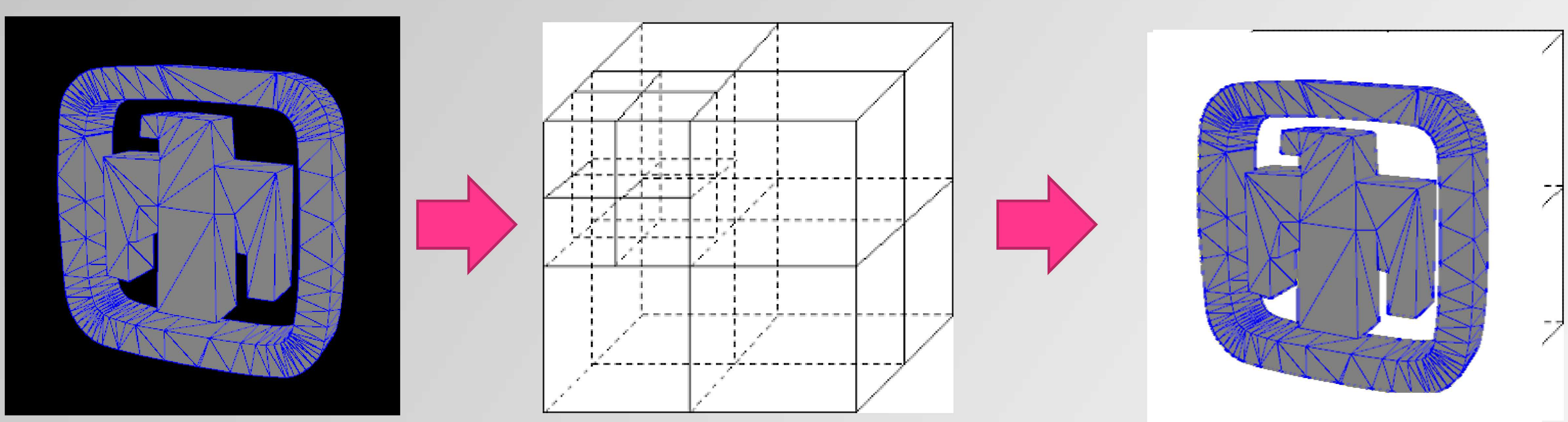

Figure 3: Octree elimination for ray tracer

Voxelization

In order to fill the organic shapes of CAD models, tetrahedral voxels were chosen. GADRAS already has methods for reducing custom voxels into point sources based on the six shape primitive's respective voxels. Each of these voxels can be defined to have three driving dimensions, so tetrahedral voxels must also fit this three dimension rule to work in GADRAS. Finally, there must be an initial mesh for GADRAS to reduce. For tetrahedra, a uniform grid of cubes divided into five tetrahedra is used. A full example of voxelization using tetrahedral voxels can be seen in Figure ###.

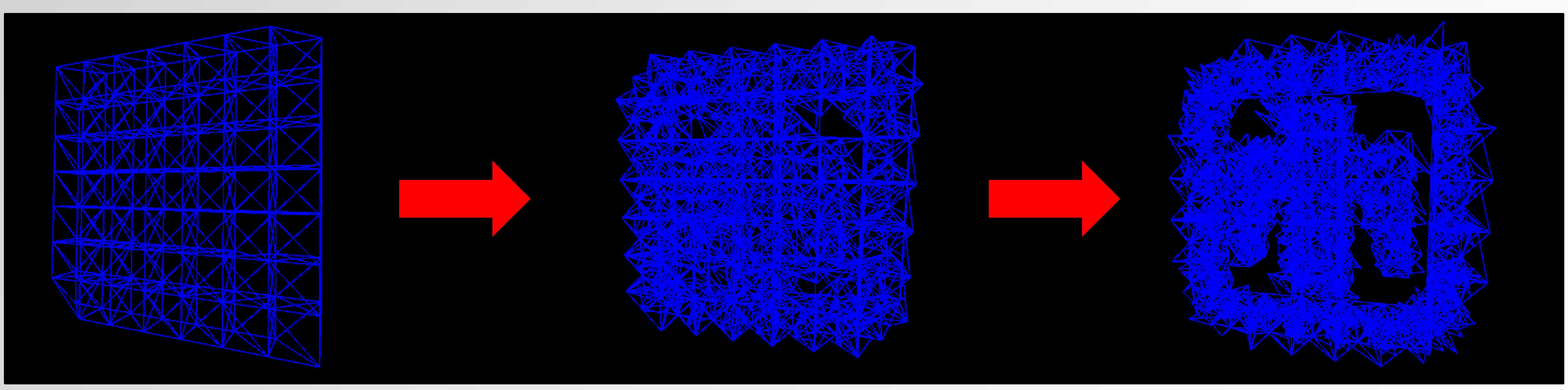

Figure 4: Voxelization using tetrahedral mesh

Future Work

Although the above implementation works at a reasonable speed, more optimization will be done on the ray tracer by using non-cubic octree division, and analysis of optimal depth and fill count. Voxelization will be optimized by exploring better options for the initial mesh, and better determination of the optimal split position. Additionally, validation is still necessary and will be performed against MCNP and comparison to experimental data.

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