Automatic Triangulation of Non–Trivial 3–Dimensional Domains Using Multiple Element Types

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Abstract

This talk describes work in progress on three–dimensional semiconductor modelling at the Integrated Systems Laboratory on integration of the geometric techniques of boundary manifold descriptions and Delaunay triangulation with conventional hexahedral mesh generation to produce refinable meshes with low element count which also accurately simulate complicated boundary domains.

The interest in three–dimensional modelling of the semiconductor equations need not be justified here.

At the Integrated Systems Laboratory, a team of 5 people are working on this problem. Results presented here have to do with mesh generation aspects of the problem leading to equation assembly.

Several issues were addressed pertaining to mesh generation:

- generality of the representation used
- element efficiency
- refineability

Generality of representation essentially implies supporting of tetrahedral elements. Because simulations involving tetrahedral elements only can have quite high element counts, considerations of element efficiency mandates the support of more than one kind of element. This represents a change in habitual procedure with regard to many finite–element codes in current use. Under such circumstances, even the data structure to be used was unknown when we started.

We have developed a fully dual data stucture for the representation of 3–dimensional complexes, called the HexBlock data structure. This structure is different from structures for the same purpose which use hyperplane ensembles in that it has been optimized to favor the topological neighbor operations used in doing finite–element assembly. We have since heard of similar structures developed concurrently at Princeton and IBM.

In mesh element generation for the semiconductor equations, it is of interest to generate elements of the greatest normalized volume possible. Because the Delaunay triangulation is known to produce elements for a given set of nodes which in some sense 'best' fulfills this condition (and because the *problème célèbre* in all research into structures of this type is to compute Delaunay), we have also developed a Delaunay triangulation algorithm. This algorithm when first reported was unique in its use of the dual Gaussian diagram space. Also noteworthy is its ability to deal with degeneracies, and its dimensional independence.

These tools are used heuristically to 'triangulate' the boundary regions of the different substrates of an NMOS transistor, and to merge the results with a hexahedral mesh covering the interior. Both meshes are generated automatically, based on an element density profile function. The resulting grid generated is used as input to a multi–element assembly procedure to form equations for solution by direct methods.