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INTEGRATION OF AUTOMATIC MESH GENERATION FOR
SIMULATION OF CONTAMINANTS IN SOILS AND GROUNDWATER

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ABSTRACT:

An automatic mesh generator was modified and implemented that conforms to arbitrarily shaped two dimensional geometries. The grid generator requires no user intervention and can handle multiple component systems. The routine is well suited to dynamic situations experiencing large geometrical change such as in solidification or ground freezing processes. Additionally, the system has the option to output its results in a 2D Groundwater Modeling System format and a 3D extruded prism layer compatible with the GMS interface and the Waterways Experimental Station's 3DFEMFAT finite element code for flow and contaminant transport in saturated and unsaturated soils. A uniform equilateral triangular grid overlays the physical domain. Increased resolution can be specified in areas of interest or in areas undergoing large geometrical change such as occurs during solidification. All elements exterior to the physical domain are eliminated. The elements closest to physical boundaries are adjusted to conform to the physical shape, and a smoothing operator is employed to assimilate these adjustments. Interior boundaries of multiple component systems are retained. This mesh generation strategy virtually eliminates user interaction which reduces the actual time required for solution substantially.

The adaptive finite element mesh generator was applied to an illustrative subsurface soil situation. Therein, the multiple levels of resolution are presented as well as the various output formats.

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INTRODUCTION:

Numerous computer-aided design packages (CAD) are available for displaying geometric objects. Using today's powerful personal computer (PC) systems, some of these CAD products have become fully operational at the PC level.[1] However, a subsequent operation is required that converts the CAD shape description to a valid numerical description compatible with traditional finite element or boundary element solvers. This usually involves construction of a numerical mesh which is a tedious, time consuming task without some form of automated mesh generation procedures. Grid generation codes exist for specific applications where the component shape is known apriori.[2] However, these techniques are not usually viable for arbitrarily shaped objects. As an additional complication, the initial design layout of a subsurface region may undergo several iterations as more borehole information is acquired, with each iteration requiring a different mesh, before a flow and contaminant transport simulation is finalized.

Investigators have expanded the capabilities of mesh generation routines for arbitrarily shaped objects or geometries.[3-9] The majority of these algorithms use triangle and tetrahedral elements in two and three dimensional space, respectively. These elements are the simplex elements of their respective dimensional domains and have the ability to completely define geometries without overlap or voids. A highly successful triangulation procedure is based on constructing Voronoi regions followed by the Delaunay triangulation.[8,9] This process requires a previously defined set of numerical points and involves the calculation of localized circular or spherical domains about each nodal point. These radial calculations can be CPU intensive. The work presented herein avoids the intensive radial computations and provides a mesh generation preprocessor that is compatible with the main finite element program, 3DFEMFAT. The mesh generation output is also directly compatible with the GMS pre- and post- processor for display of results which provides the user with a vehicle for interactive steering of the parameter and geometry specifications during the calculations.

PROBLEM STATEMENT AND FORMAT REQUIREMENTS:

Key to this mesh generation routine is the description of the geometric boundaries. A simple, yet unambiguous, boundary definition exists using linear boundary elements. Consider the situation where three distinct physical bodies meet as in Figure 1. Node #2 is common to each zone which illustrates the difficulties of defining zones uniquely through boundary nodes. Alternately, consider the boundary elements. Elements E_1 through E_3 have node #2 associated with their elements, yet element 1 separates zones 1 and 2 uniquely.

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