

Enhanced Elliptic Grid Generation

Decay parameters that govern grids near boundaries are determined automatically.

Ames Research Center, Moffett Field, California

An enhanced method of elliptic grid generation has been invented. Whereas prior methods require user input of certain grid parameters, this method provides for these parameters to be determined automatically.

“Elliptic grid generation” signifies generation of generalized curvilinear coordinate grids through solution of elliptic partial differential equations (PDEs). Usually, such grids are fitted to bounding bodies and used in numerical solution of other PDEs like those of fluid flow, heat flow, and electromagnetics. Such a grid is smooth and has continuous first and second derivatives (and possibly also continuous higher-order derivatives), grid lines are appropriately stretched or clustered, and grid lines are orthogonal or nearly so over most of the grid domain. The source terms in the grid-generating PDEs (hereafter called “defining” PDEs) make it possible for the grid to satisfy requirements for clustering and orthogonality properties in the vicinity of specific surfaces in three dimensions or in the vicinity of specific lines in two dimensions.

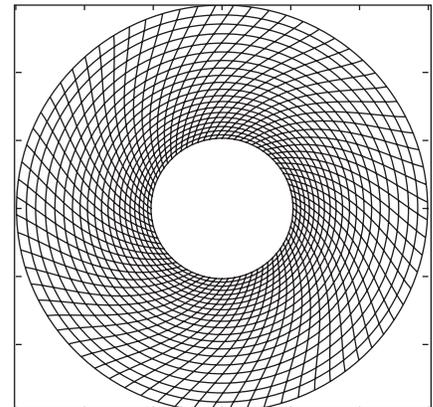
The grid parameters in question are decay parameters that appear in the source terms of the inhomogeneous defining PDEs. The decay parameters are characteristic lengths in exponential-decay factors that express how the influences of the boundaries decrease with distance from the boundaries. These terms govern the rates at which distance between adjacent grid lines change with distance from nearby boundaries.

Heretofore, users have arbitrarily specified decay parameters. However, the characteristic lengths are coupled with the strengths of the source terms, such that arbitrary specification could

lead to conflicts among parameter values. Moreover, the manual insertion of decay parameters is cumbersome for static grids and infeasible for dynamically changing grids.

In the present method, manual insertion and user specification of decay parameters are neither required nor allowed. Instead, the decay parameters are determined automatically as part of the solution of the defining PDEs. Depending on the shape of the boundary segments and the physical nature of the problem to be solved on the grid, the solution of the defining PDEs may provide for rates of decay to vary along and among the boundary segments and may lend itself to interpretation in terms of one or more physical quantities associated with the problem.

The limiting form of the defining equations used in this method is partly analogous to boundary-value PDEs for heat transfer over long, thin fins governing convection and conduction of heat across the boundary segments and heat generated or lost within the volume to be enclosed by the grid. Each limiting form of the defining equations is deemed to be valid near at least one boundary segment. Each such equation includes at least two independent Cartesian coordinate variables and at least one generalized coordinate as a dependent variable, the integral form of which constitutes a boundary constraint. Boundary conditions analogous to temperature and thermal conductivity prescription can be specified by the user. In addition, as an essential element of the method, a selected power of at least one heat-transfer coefficient must correspond to at least one decay parameter (which, as stated above, the user does



A Grid in an Annulus between relatively rotating inner and outer circles was generated by the present method.

not specify) near at least one boundary segment, and such a heat-transfer coefficient evolves according to the boundary constraint.

The figure presents results of application of the method to a two-dimensional annular region. This example illustrates the clustering of grid points near the inner boundary of the annulus. It also illustrates how the grid evolves automatically with one or more time-varying boundary condition(s) — in this case, rotation of the inner boundary relative to the outer boundary or vice versa. In a case involving time-varying boundary conditions, the solution at each time step serves as a starting point for the solution at the next time step.

This work was done by Upender K. Kaul of Ames Research Center.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Technology Partnerships Division, Ames Research Center, (650) 604-2954. Refer to ARC-14710-1

Automated Knowledge Discovery From Simulators

Active learning process efficiently explores simulator input space.

NASA's Jet Propulsion Laboratory, Pasadena, California

A computational method, SimLearn, has been devised to facilitate efficient knowledge discovery from simulators. Simulators are complex computer programs used in science and engineering to model diverse phenomena such as fluid

flow, gravitational interactions, coupled mechanical systems, and nuclear, chemical, and biological processes. SimLearn uses active-learning techniques to efficiently address the “landscape characterization problem.” In particular, SimLearn

tries to determine which regions in “input space” lead to a given output from the simulator, where “input space” refers to an abstraction of all the variables going into the simulator, e.g., initial conditions, parameters, and interaction equations.