

Mesh Generation for environment security applications: Grid Pro initiative at ECPP

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Computational analysis of continuum physical processes is done for practical scientific and engineering applications. At the very foundation of virtually all such analysis is the mesh (or grid) upon which the governing equations of continuum physics are digitized for computer simulations. The mesh represents very directly the digital description of the continuum field about and/or within the very real geometric objects that we manufacture and study. These studies span a very broad range of topics and industries. GridPro developed by Peter Heiceman at ECPP, the environmental crime prevention program, employs a technology that will transform the way the computational analysis for continuum physics is done.

At the current stage of knowledge, mesh generation is broadly split into structured and unstructured approaches. There are, of course, various methodologies attached to these approaches as well as various hybrids between them. The current user perception is that structured grids typically offer higher quality but at the expense of a great amount of human labor while unstructured grids greatly reduce the human labor at the expense of quality. A part of the reasoning is that unstructured provides a more flexible format than structured and thus is the only way to realistically consider problems with excessively massive geometric complexity. Another part of the reasoning is that structured provides a better format for quality than unstructured and that such quality is necessary to assure the accurate modeling of physics. Scientists and engineers can always argue about how much accuracy is needed for their particular cases. However, from a broader perspective it does not make much sense to use unstructured to more rapidly and easily arrive at the wrong answers. But then to not use it has sometimes meant to have no answers at all or to wait an absurdly long time for answers to appear. This then brings us to an impasse when we are faced with a simulation that involves massively complex geometry.

The key items that necessary to solve problems of massive geometric complexity are automation and quality. The starting point is the technology represented by the GridPro code. This technology is differentiated from the others in its topology paradigm. In simple terms, topology is just the desired pattern of points irrespective of geometric details. This alone represents a great reduction in the data required to create a grid (or mesh) about complex geometry. While the topology is globally unstructured, it is locally structured. Moreover, GridPro has a built-in optimizer for quality which provides quality levels well beyond all currently available structured grid generators. It has been shown in a very large number of simulations that the GridPro quality level has resulted in more accurate answers and much faster convergence rates for analysis codes (at least 3 times faster) when compared with other structured grid generators which in themselves provide similar margins over unstructured generators.

In a very direct way, GridPro represents the reduction of multiblock grid generation to that of topology generation. Once the topology has been generated, the grid generation

is fully automatic. The grid then appears both in the volume and on the surface. At the present time, however, the act of topology generation is done in an interactive way.

The main purpose is to automate the topology generation process. The options to be considered for this action stem from what we know about the medial axis transformation, trimmed transforms, fuzzy logic, and rule based sorting. Each of these items represents a detailed discussion too lengthy for this forum. The benefit of a success in the automation of topology generation is the fully automatic grid generation for a wide range of simulations. This will capitalize on the flexibility of topology and the quality of the optimized grid. The result will be to achieve what was sought with the pursuit of unstructured grid generation while also getting a quality level well beyond normal structured grids. The implication is that cases with massive geometric complexity can be readily simulated and studied with reliable answers.

In addition, an allied project is also being considered. That is the development of a CAD system unlike others. It is to be based upon global actions which will simplify users' interactions. With current CAD systems users typically do a considerable amount of local work which can be reduced and at the same time can be greatly improved in quality. The intent is to add non standard techniques to CAD and to translate the results into standard CAD folklore into such objects as NURBS etc. The underpinnings of this action will rely upon advanced mathematics. A part of this technology can and will be used for some technical aspects of the automatic topology generation.