ViennaMesh - a Highly Flexible Meshing Framework

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Abstract

While the mesh size 'h' is the main parameter for error estimations in finite element methods, a common assumption is that all cells of a mesh are of 'good' shape. What can be considered a 'good' shape is, however, problem-specific [1]. Even though numerous existing meshing algorithms are able to produce meshes with certain properties, such as the Delaunay property with guaranteed quality and isotropic meshing elements, e.g. [2], the simultaneous use of different meshing algorithms is challenging because of non-unified interfaces. We resolve this deficiency by presenting results and experiences gathered during our work on ViennaMesh [3], a meshing framework offering a common programming interface for a plethora of internally and externally provided meshing algorithms. We discuss the set of abstract concepts defining the generic requirements on functionalities and data structures, which allow for wrapping external data structures and software libraries such as Tetgen, Netgen, and VERDICT. These abstract concepts guarantee exchangeability of algorithms and functionalities in a convenient way. The internal data structure of ViennaMesh was developed with a high level of flexibility regarding the topological structure of mesh elements in mind. The topological connectivity of mesh elements is inspired by [4], and was extended to allow for a more general setting. To avoid performance issues of traditional object-oriented approaches, the required data structures can be configured at compile time to match the particular needs using C++ meta programming techniques. This enables to support the full family of simplices and hypercubes of arbitrary order. Finally, we present applications of ViennaMesh to finite element problems in microelectronics for the solutions of the drift-diffusion system. The required meshes tend to have complicated geometries and very thin layers at material interfaces as well as strong variations of material properties.

References

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