About me

My name is Jingyi Wang, a graduate student in Mechanical Engineering department. I am currently exploring possible projects for my doctoral studies. My interest lies in numerical analysis, both mathematical theories and computational implementations, mainly finite element methods. Although well-established, finite element method has its limitations in many areas and not much has been done in order to parallelize the algorithms in order to solve problems dealing with large scale domain or evolving meshes. Continuity imposed on conventional elements makes it harder to form an obvious way of parallelization, and thus discontinuous Galerkin method might be one of the possibilities to study.

Problem of interest

Discontinuous Galerkin method is a numerical method still under extensive research and not yet implemented in mainstream FEM commercial software. The method combines features of the finite element and the finite volume framework. The basic idea of meshing domains and concepts of elements and shape functions are identical to those of finite element method. But it allows discontinuities between element interfaces and exploits flux functions as in finite volume method to incorporate interactions between elements. As for mechanical engineering applications, the method is successful in some challenging applications like fluid-structure coupled problems, especially those with discontinuities.

In some simple sample problems with much refined yet structured meshes, parallelization comes natural as elements can carry out calculations simultaneously and independently before inter-element effects are considered. Among them, problems that enjoy elements with the same mass or stiffness matrices are the most apparent examples. More complex problems, however, needs much more attention. In the paper given below, the method, while used on some compact stencil, is parallelized on MIMD computers with scaled efficiencies exceeding 90% and can model problems in complicated geometries more easily than traditional finite difference schemes. The authors reported that in the parallel MIMD hp-method, load imbalance becomes a serious difficulty, but the quadtree data structure they used may simplify the load balancing process.

While some work has been done in an effort to parallelize the finite element method to deal with difficult problems like those with constantly changing boundaries, much needs to be researched before some problem-independent result can help generalize a solution.

Reference: