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MULTIOBJECTIVE OPTIMIZATION ALGORITHMS FOR UNTANGLING AND MESH QUALITY IMPROVEMENT OF QUADRILATERAL MESHES

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Computational simulations of physical phenomena, such as fluid dynamics or structural analysis, involve the numerical solution of partial differential equations (PDEs) on meshes. To obtain reliable simulation results, the PDEs must be solved accurately and efficiently.

Two-dimensional PDE simulations which employ quadrilateral meshes typically result in more accurate solutions than those which use triangular meshes [1] since quadrilateral elements can be aligned with the fluid flow. In addition, quadrilateral meshes typically contain fewer elements than triangular meshes and thus result in more efficient simulations. Furthermore, quadrilateral meshes are often preferred in dynamic simulations such as car crashes or fracture studies since constant-strain triangular elements typically perform poorly in bending.

In finite element analysis, a mesh is said to be tangled if one or more elements has a negative Jacobian determinant. Meshes can become tangled through mesh deformation or smoothing or by another means. Hence, mesh untangling and mesh quality improvement are two important areas of investigation.

Traditionally, separate methods have been applied to perform mesh untangling followed by mesh quality improvement. It is typically the case that greater computational expense is occurred via this two-step process than when the two steps are combined into a single step.

In this talk, we will present our multiobjective optimization methods for mesh untangling and quality improvement. They were developed by combining separate objective functions for untangling and mesh quality improvement into a single objective function using ``no articulation of preferences" [2]. The implemented multiobjective optimization methods are based on the exponential sum, objective product, and equal sum optimization methods. Our methods are an extension to the previously established multiobjective mesh optimization framework for untangling and quality improvement of simplicial meshes [2]. We present results from numerical experiments demonstrating our methods' success.

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