A Multiobjective Optimization Approach to Untangling and Mesh Quality Improvement of Quadrilateral Meshes
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ABSTRACT

The accuracy of mathematical models and numerical methods are of significant importance to obtain reliable simulation results. Therefore, employing a mesh for a partial differential equation (PDE) simulation which results in less analysis error is desirable for such modeling. Quadrilateral meshes often contain fewer elements than triangular meshes, and thus result in more computationally efficient PDE simulations. Similarly, their associated PDE analyses are typically more accurate [1]. Furthermore, quadrilateral meshes are preferred in dynamic simulations such as car crashes or dynamic fracture studies. The motion of the mesh elements in such computational studies results in tangled meshes which makes mesh untangling and quality improvement methods important topics of study.

Mesh tangling occurs when mesh elements overlap. In order to address this issue, various untangling methods have been introduced in the literature. Following the untangling phase, mesh quality improvement is typically applied to the resulting mesh in order to improve its quality. A common theme for the previous methods is the application of these two processes as separate steps rather than applying both in one step. This usually results in greater computational expense.

In this talk, we will present our method for low-order mesh untangling and mesh quality improvement. Our method is an extension to the previously established multiobjective mesh optimization framework for untangling and quality improvement of low-order simplicial meshes [2]. Our approach is focused on identifying multiple quality metrics for the mesh and optimizing all of these (often competing) metrics in a multiobjective optimization framework. For each case of mesh untangling, multiple objective functions are defined. These functions are then combined into a single objective function with no “articulation of preferences” [2]. The implemented multiobjective techniques include the exponential sum, objective product, and equal sum optimization methods.

In this work, we present several examples demonstrating the performance of our multiobjective mesh quality improvement and untangling approach on some realistic geometries involving quadrilateral meshes. Extending the developed method to handle high-order quadrilateral meshes is the next step of our research.

REFERENCES

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