Reusable Software Components in Mesh Generation

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PROJECT SUMMARY

Computational Geometry (CG) is an important component in various industrial applications such as mesh generation, computer vision, computer graphics, GIS etc. In most of the cases robustness rather than efficiency is of prime concern in adopting to a CG component. Computational Geometry poses various difficulties in all aspects of software development, i.e. algorithmic design, zero-tolerant numerical precision implementation, testing and debugging. In fact, sometimes, innocuous looking algorithms can have detrimental effects on the output which might be totally unacceptable by the end users. In 3D, debugging for the source of errors can be really a nightmare without the aid of interactive visualization systems. In our view, using modern software engineering practices, combined with modern software tools such as rigorously tested reusable mathematical components, generic programming, design patterns, invasive software components, hybrid programming and documentation tools can be applied to achieve reliable and easy to use software component.

In this project, we will apply these principals in developing a 3D Mesh Generation component, which is based on Delaunay triangulation method. This module is a part of the **Adaptive Software Project** of National Science Foundations' ITR project.

Intellectual Merit

Reusing software has long being identified as the best strategy to overcome the difficulties in complex and large scale software development. In my view this trend will further increase with the standardization of C++ in 1998, and emergence of Java as programming language.

The success of BLAS, Scalpack, STL, CGAL etc. have enhanced our understanding of reusable software components. The secrets behind their success are the following

- These components have very-2 simple interfaces and well documented.
- These components have very light lower-level kernels which depends on the platform and computer architecture. These subset, separates the hardware dependent modules which are tunable for high performance on almost every platform.

This success model could be applied for other domain specific applications. I have been doing research on **Mesh Generation** which is one of the most critical component in Fluid Dynamics and Structural Engineering computer simulation. Many of these applications require extremely fine discretization $(10^6 - 10^8 cells)$ of the geometric space. Implementation of geometric algorithms is a non-trivial task and using modern software tools and practices, how we can achieve a reliable and robust software component, that is really a challenge worth accepting.

Broader Impact

We hope that this project will be interesting and important for few reasons mentioned below

1. It will improve our understanding in developing important software components which are vital for industrial applications of CG related algorithms.
2. Recently most of CAD companies are focusing on integrating their software with mesh generation capabilities. Our work, may be able to help in designing new systems.
3. Perhaps this will be the first demonstration to show the benefits of modern software design methodologies in mesh generation.