The “Smooth” Challenge

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1 Introduction

The “Smooth” program is a mesh pre-processing algorithm responsible for improving a mesh characteristic, aiding the solution of discretized partial differential equations. Given a triangular disretization in 2D, the algorithm computes the "quality" of the individual triangle faces based on a nonlinear combination of the components of a metric tensor at each of the nodes of that triangle. In our simulations, a suboptimally constructed mesh typically sees an improvement of 6% with the minimum quality of any triangular face increasing 30%. We investigated various performance enhancements available on the Intel Xeon CPU E5606 2.13GHz with 4 cores by parallelising via OpenCL on the NVIDIA GE Force 570 (GF110 architecture), available on the Graphics machines in the computer lab. Aside from OpenCL v. 1.1, we used the GCC 4.6.3 compiler with -O3 maximal optimisation.

2 Profiling the Code

We initially attempted to optimise the serial version of the code on an Apple MacBook Air (with Intel i7 2.0GHz) with XCode, GCC 4.2 and Instruments for profiling. This process identifield the code spending 60% of the time in `element_quality`, which is used to evaluate the quantitative effect of local changes to node coordinates within a mesh. For a node neighboring n triangles, $2n$ calls are made to this function. Furthermore, if N nodes exist in the mesh and we use I iterations to converge to a more optimal mesh, the total number of these calls is bounded by:

$$2N \cdot n\Delta(M)$$

where $\Delta(M)$ is the maximum degree of the mesh.