Parallel finite element analysis using the Intel Xeon Phi

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This paper describes the porting of the open source engineering software ParaFEM to the Intel Xeon Phi processor. ParaFEM is a parallel library for general purpose finite element analysis that has been written in Fortran and uses MPI for message passing. It is supplied with a set of driver programs or "mini Apps" for solving different types of engineering problem. The software is described in the text book "Programming the Finite Element Method" [1]. It has been used on various HPC systems including those at the Hartree Centre; the UK's National Facility ARCHER and systems belonging to PRACE. Recent scientific application areas include the evaluation of materials for fusion reactors [2]; assessing the structural integrity of nuclear power plants [3]; developing a multiscale modelling platform using cellular automata [4] and understanding microstructural deformations in bone [5].

ParaFEM uses iterative Krylov solvers that are implemented using a matrix free or element-by-element strategy [6]. No global matrix is ever formed and this approach suits the small memory footprint (per core) of the Intel Xeon Phi. The run time of the solver is dominated by large "do loops" of small matrix-vector multiplications, so getting good performance on the processor requires optimising this type of computation. In the presentation, the authors will compare the floating point and run time performance of a number of different optimisations. Some of these are problem specific for certain types of engineering analysis and others exploit the Xeon Phi architecture, for example through the use of mixed mode OpenMP/MPI. This talk will be of particular interest to conference attendees who may wish to evaluate the Intel Xeon Phi for scientific computing.

Key words: Finite element method; Low power computing; Energy efficient computing; Parallel computing

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