Redundancy, retiming and data flow in compiling finite-difference applications for manycore architectures

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Background

The finite difference method is the most widely-used approach to solving partial differential equations in computational science and engineering – with important applications from subsurface image reconstruction to fluid dynamics to materials science and beyond. Finite difference solvers have characteristic loop and data-access patterns that benefit from optimisations that rely on application knowledge not available in general-purpose compilers. Devito, a software developed in the OPESCI project, provides a high-level language for the finite difference method that opens up the scope for such domain-specific compiler techniques.

Project aims

The goal of this project is to explore this frontier. The key idea we aim to exploit is symbolic manipulation of algebraic expressions to expose redundant computations, and to do this in concert with modelling of when to evaluate such expressions, where to store them, and when pre-computing them is better than recomputing them. We think there is a way to do this in a unified, perhaps even optimal, way.

Research methodology

A key element of our research philosophy is the rigorous development of software tools that can be evaluated on diverse real-world problems of industrial and scientific importance. The work will be driven (at least initially) by applications in seismic inversion, which provide a rich spectrum of challenges. We will target the most sophisticated parallel hardware platforms available, including manycore, multithreaded and wide-vector architectures – such as Intel's Xeon Phi and Skylake processors. This is an *interdisciplinary project* between the Earth Science and Engineering department and the Computer Science department. As such, the candidate will work in strict contact with world leading experts in Mathematics, Geophysics and Computer Science, from both academia and industry (in particular, Intel Corporation).

Candidate profile

For this project, candidates should have a significant background in either computer science or applied mathematics. Students, however, will receive extensive training in the core areas of the project (e.g., compilers, finite differences), through lectures, workshops and direct interaction with members of the team and external collaborators.

Contact

For further information, do not hesitate to get in contact with us:

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Useful links

www.opesci.org - For information about Devito and the OPESCI project, with links to our publications and international collaborations.
https://github.com/opesci/devito - Devito source code repository.
https://www.slim.eos.ubc.ca - We have a strong collaboration with the SLIM group at University of British Columbia, where Devito is used to study advanced subsurface image reconstruction methods.