PROMISE: Dynamic mixed precision analysis for numerical algorithms

Xinye Chen*[1], Thibault Hilaire[1], and Fabienne Jézéquel[2]

[1]LIP6 – Sorbonne Université, CNRS, LIP6, F-75005 Paris, France – France
[2]LIP6 – Sorbonne Université, CNRS, LIP6, F-75005 Paris, France – France

Abstract

Achieving optimal performance in numerical computations often hinges on aggressively quantizing arithmetic and data to low-precision formats or rigorous rounding error analysis so as to retain the numerical accuracy. The PROMISE framework provides a unified, task-specific validation platform that automates dynamic precision tuning, enabling a balance between computational efficiency and numerical fidelity. In this talk, we introduce novel enhancements to PROMISE, including expanded precision options (e.g., custom floating point types), which streamline the exploration of low-precision configurations. We apply these advancements to evaluate a suite of well-established numerical algorithms, including iterative linear solvers like conjugate gradient methods, as well as compute-intensive kernels. Our experiments reveal the potential for significant performance gains-up and memory reduction - by leveraging low-precision settings, particularly for large-scale problems like sparse matrix computations. We also address challenges, such as numerical sensitivity in high-dimensional systems, which can limit low-precision adoption, and propose strategies to overcome them, such as relaxed convergence criteria and matrix preconditioning. Through detailed case studies, we offer actionable insights into selecting optimal precision levels for diverse algorithms, demonstrating PROMISE's versatility as a benchmarking tool for modern approximate computing. This work underscores the transformative potential of automated precision tuning in enhancing efficiency while maintaining robustness across a spectrum of numerical applications.

*Speaker