ETH zürich

Master thesis / Semester project

Development of distributed algorithms for the selected multiplication of structured sparse matrices

Description:

Sparse matrices represent one of the most widely used data-structures in scientific-computing. However, performing linear algebra on such matrices is not easy.. Many challenges arise, may they be performance related (data-reuse..), or memory related (fill-in during decomposition..).

On the other-hand, dense representation issue very high compute throughput on GPU, but are of no practical use when the size of the matrices grows.

We are interested by the best of both world: *Structured Sparse Matrices*. All non-zeros elements of such matrix lies into a pattern. The density inside of this structure is high (> 30%), which allow a dense-blocked representation of the matrix. We can then perform dense (but tailored!) block operations on theses matrices, harvesting the memory advantage of a sparse representation and the computing advantage of dense operations!

Of particular interest are matrices of type: Block-tridiagonal (BT) and block-tridiagonal with arrowhead (BTA). Theses matrices arise in many scientific applications and are closely related to interacting elements within finite-difference/elements models.

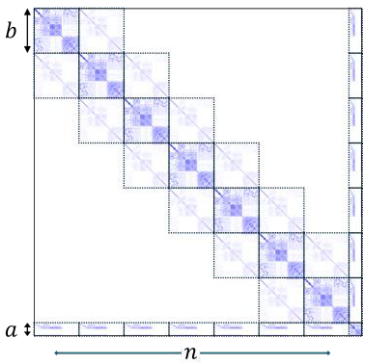

Figure 1. Block-tridiagonal with arrowhead (BTA) matrix from statistical temperature prediction.

Scope:

The scope of the project is:

- Development and implementation of sequential and distributed algorithms for matrix multiplication of BT and BTA patterns,
- Communication/Compute overlap using CUDA streams,
- Performance analysis of the algorithms (alpha-beta model) and benchmark of the implementations.

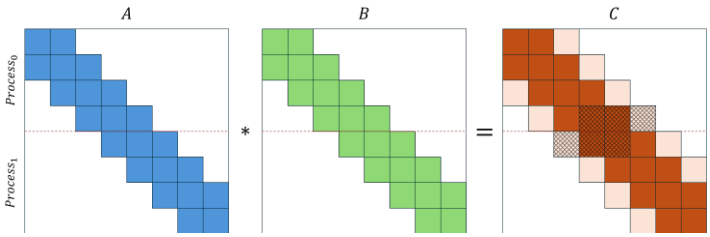

Figure 2. Distributed matrix multiplication of two block-tridiagonal (BT) sparse matrices. In hatches are represented the blocks that need communications between the processes to be computed.

Self-assessment: Do I fit?

Evaluate yourself, the more stars ✪ you collect, the better of a fit.

- I'm interested in linear algebra and how we can develop tailored algorithms ✪ ,
- I want to developed in python using NumPy ✪, CuPy ✪,
- I want to learn about MPI ✪,
- I'm motivated and autonomous ✪.

Contact:

- Maillou Vincent (ETZ J 81), vmaillou@iis.ee.ethz.ch
- Prof. Luisier Mathieu (ETZ J 82), mluisier@iis.ee.ethz.ch

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