Personal projects
MS HPC-AI - Linear algebra in data analysis and scientific computing

Christophe Bovet

December 2020

Common remarks

Three different subjects are proposed, each of them is the suite of one practical work. These subjects are line of thought and if it is too easy, feel free to go further. You have until the 17th of January to do one of these subjects and to send me (at `christophe.bovet@onera.fr`) a pdf report (presentation or real report format). You can add the answers of the corresponding practical work in the report. Also, you have to make an archive of your codes (and computations) and to give me the permissions to access it on the CEMEF cluster (in `/gext/your-login/project-your-login.tar.gz` for example).

Subject 1: A deeper look on improved CG methods

The aim of this subject is to get a deeper look into communication hiding and avoiding techniques. It follows the first practical work. The file `tp.cpp` is the starting point of the project.

Required work

- Modify the file `tp.cpp` to be able to solve block diagonal systems.
- Using the paper of Ghysels and Vanroose, implement the preconditioned CG version of Chronopoulos and Gear and of Ghysels and Vanroose.
- Propose a block diagonal system to be solved and try several block preconditioners (diagonal, tridiagonal). Then perform a weak scalability study.

Subject 2: Geometric multigrid in 2D

The aim of this subject is to get a deeper look into geometric multigrid methods. It follows the second practical work.

Required work

- Adapt the code to be able to solve the problem in 2D on the unit square.

$$-\Delta u(x,y) + \sigma u(x,y) = f(x,y) \text{ in } \Omega \quad \sigma \geq 0$$
$$u(x,y) = 0 \text{ on } \partial\Omega$$

- Compare the convergence of the V-cycle and the W-cycle for various sigma and number of grid levels.
- Implement the full weighting and half-weighting injection operator and compare the results
- Anisotropic problem, modify your code to be able to solve the problem

$$-\frac{\partial^2 u(x,y)}{\partial x^2} - \epsilon \frac{\partial^2 u(x,y)}{\partial y^2} = f(x,y) \text{ in } \Omega$$
$$u(x,y) = 0 \text{ on } \partial\Omega$$

  Observe the convergence behaviour with the standard coarsening for various values of ϵ. Try to find a better coarsening strategies.

Subject 3: Deeper look on BoomerAMG

The aim of this subject is to apply BoomerAMG on a real world sparse linear system. It follows the third practical work.

Required work

- Modify your code to be able to solve a matrix in MatrixMarket format taken from `https://sparse.tamu.edu/`. You need to write a method that split this matrix in order to distribute it among all processors.
- Perform a strong scalability study for this matrix with all default parameters.
- Play with the parameters and try improve the scalability of the solver.