Lab 09 - matrix-free computations with MPI

Numerical Solution of PDEs Using the Finite Element Method

MHPC P2.13_seed

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1. Run the included step-37 example. Compile the code in release mode ("make release") and run with 1 and 2 MPI processes. Record the solver time and the number of iterations.
2. This example uses a geometric multigrid preconditioner that gives constant iteration times as the mesh is refined, as opposed to the `PreconditionIdentity` that was used in the early labs. Check the number of iterations with the conjugate gradient method.
3. Enable the code `compare_performance_matrix_vector()` in the `run()` function. Which of the matrix-based and the matrix-free product is faster on your machine?
4. Change the polynomial degree from `2` (set at the top of the file through the variable `degree_finite_element`) to `1` and `3`. Observe the difference in the performance of the matrix-vector product. Be careful with the largest problem size and degree `3` as the sparse matrix could run out of RAM memory.
5. Compare the ratio between the sparse matrix-vector with the Trilinos sparse matrix and the matrix-free `LaplaceOperator` when run on `1` processor core with the ratio when using all processors on your system. What could be an explanation of the difference in the ratio?