

## Exercises for Advanced Topics in High Performance Scientific Computing

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Exercise Sheet 12 (until January 20, 2016)

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### Exercise 12\*

Use the finite difference method to discretize the Laplace equation on the unit square

$$\Delta u(x, y) = 0, \quad (x, y) \in \Omega := (0, 1) \times (0, 1) \quad (1)$$

with the boundary conditions given by

$$u(x, 0) = u(x, 1) = 0, \quad u(0, y) = u(1, y) = \sin(\pi y), \quad x, y \in [0, 1]. \quad (2)$$

Solve the resulting linear system  $Au = f$  with the Jacobi method with an initial guess  $u^{(0)} = u_0$  and for  $k > 0$  calculate

$$u_i^{(k+1)} := \frac{1}{a_{ii}} \left( f_i - \sum_{\substack{j=1 \\ j \neq i}}^n a_{ij} u_j^{(k)} \right), \quad i = 1, \dots, n. \quad (3)$$

Implement the Jacobi iteration in C/C++ with a matrix-free approach and vectorize the algorithm with AVX intrinsics for a single core and parallelize the matrix evaluation using OpenMP. Terminate the Jacobi iteration if the error norm  $\|f - Au\|_2 < 10^{-6}$ . Analyze the parallel efficiency of the Jacobi solver in a graph for different grid sizes and number of threads.

\* Place all source files of the exercises in a folder named `Exercise12` in your home directory on the `mephisto.uni-graz.at` cluster.