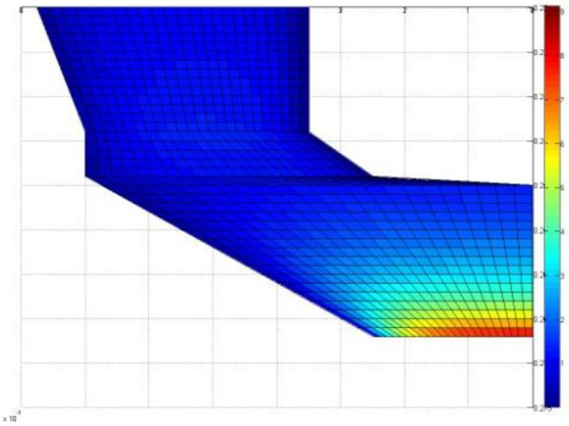
Improvement of the computational performance of a numerical algorithm for polymer molding injection and code engineering

Project summary



Client:	HRS - INglass
Partner:	-
Year:	2015-2017
Service:	Numerics & HPC
Sector:	Industrial Engineering
Project in numbers:	1200 lines of code
Coding language:	Matlab / C++
Other details:	-

Abstract

The aim of the project is to improve the computational performance and accuracy of a numerical algorithm specifically developed for the simulation of the polymer molding injection process. The algorithm computes the drop of pressure along each path, taking into account the viscous behavior of the polymer along with the variation of the temperature.

A basic algorithm provided by the Client has been analyzed and numerically improved in both its robustness and efficiency. Then, the code has been translated from Matlab to C++, with a significant speed-up of the resolution time.

Project description

The polymer molding injection is a challenging process, which cannot be easily simulated by means of standard commercial software. To simulate the process and control numerically the design of the injecting network, HRS-INglass has developed an ad hoc computer algorithm, specifically tailored for its injection system. The code takes into account the physical and mechanical properties of the elements (pipes, injectors, transfer) designed and produced directly by the factory.

The objective of the code, originally developed in a Matlab environment, is to compute the flow rate and the pressure loss in each pipe of the network by solving the non-isothermal flow equations of a viscous fluid. The algebraic non-linear set of equations governing the problem has been determined by the integrating numerically such differential equations, discretizing each single segment of the network in both the axial and radial direction.

The M3E team has been involved in a deep cooperation with HRS-INglass to improve the numerical efficiency, accuracy and robustness of the code. This goal has been achieved

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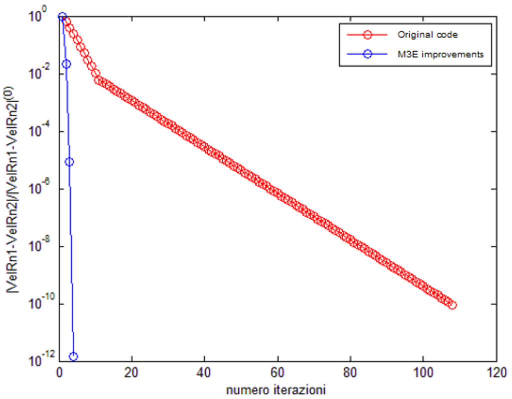
reformulating the iterative scheme originally implemented in the code.

Some of the results achieved by the project are summarized in the following figure, which show the decrease in terms of iteration number of the optimal scheme developed by M3E.



Once robustness and accuracy have been guaranteed in the Matlab code, the software has been translated into C++. The advantages of developing a C++ code is twofold. First, the computational performance of C++ is intrinsically higher than Matlab. The following table summarizes the computational time required to solve a set of standard benchmark problems using a C/C++ and a Matlab code (C/C++ computational times have been normalized to 1. Source: https://julialang.org/)

Benchmark	C / C++	Matlab
Fib	*1*	*x 26.89*
Parse_int	*1*	*x 802.52*
Quicksort	*1*	*x 4.92*
Mandel	*1*	*x 7.58*
Pi_sum	*1*	*x 1.00*
Rand_mat_stat	*1*	*x 14.52*
Rand_mat_mul	*1*	*x 1.12*

A C/C++ code can be up to 800 times more efficient than a Matlab code. The speed up gained translating the code of the project from Matlab to C++ has been equal to approximately *x 6*.

Second, a C++ library is more easily portable in different hardware environment (both desktop or serve), since an executable standalone program can be crated.

For linear algebra tasks, such as the solution of linear system, the code uses the numerical library developed by M3E, which has been optimized for a fast and efficient solution of the considered problem.

Project outcome

The outcome of the project has been first an optimized Matlab code, with a significant speed up of the solution time; second, a C++ executable program, ready to be installed in desktop and server applications.