Graph grammar based multi-frontal direct solver for isogeometric FEM simulations on GPU

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We present a graph grammar model of a multi-frontal direct solver for one and two dimensional isogeometric finite element method simulations with NVIDIA CUDA and perform numerical experiments for linear, quadratic, cubic, quartic and quintic B-splines. Finally, we estimate the computational cost of the for a parallel shared memory implementation: O(p^2log(N/p)) for 1D, O(Np^2) for 2D, as well as O(N^1.33 p^2) for 3D problems. We compare the parallel costs with the corresponding estimates for a standard sequential implementation: O((N/p)p^2) for 1D, O(N^1.5p^3) for 2D and O(N^2p^3) for 3D. We conclude the presentation with observation that computational cost of the shared memory direct solver scales like p^2 when we increase the global continuity of the isogeometric solution, which is an adventage with respect to sequential isogeometric solver scalability of the order of p^3. We conclude with a discussion on practical limitations of such GPU implementations, related to memory usage especially for 3D.

Keywords: direct solver, isogeometric finite element method, computational cost, NVIDIA CUDA