Nested Dissection for Interactive CE Applications

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Abstract

Due to recent advances in hardware development, solving computational engineering related problems in less time becomes feasible which even allows for an interactive, i. e. real time processing. While such approaches – usually referred to as computational steering or interactive computing – are well known since many years, even on modern supercomputers the complexity of the problem (amount of unknowns, e. g.) to be solved in an interactive fashion has to be kept moderate small. Otherwise, the simulation code needs too much time for response, i. e. computing an update after changes have been applied, which results in the loss between cause (user interaction such as modifications of boundary conditions or geometric changes) and effect (numerical results), hence users would not experience a *real* interaction with a running application.

To tackle this challenge of high updates rates (in the range of 1—10 Hz for a quantitative and 10—100 Hz for a qualitative analysis) sophisticated processing schemes are inevitable. Here, nested dissection (ND) is very advantageous as it allows for both an efficient organization of the solution process itself as well as for simple, but scalable parallelisation strategies. Within our researches, we have applied ND to a high-order finite element code (*p*-FEM) for the interactive structure analysis in bio-medical applications (orthopaedics). Therefore, based on CT scan data a geometric model of human femur is constructed and discretised using octrees. The resulting cells are organized in a hierarchical fashion and direct input to the structure solver. By now using the ND scheme – after an initial computation – any following computation can be reduced to a minimum amount of effort as only those parts have to be recomputed where a change has been applied. That means, while moving around an implant or changing loadings of the bone, due to the ND scheme any redundant computation can be avoided and, thus, update rates of 1—5 Hz are possible.

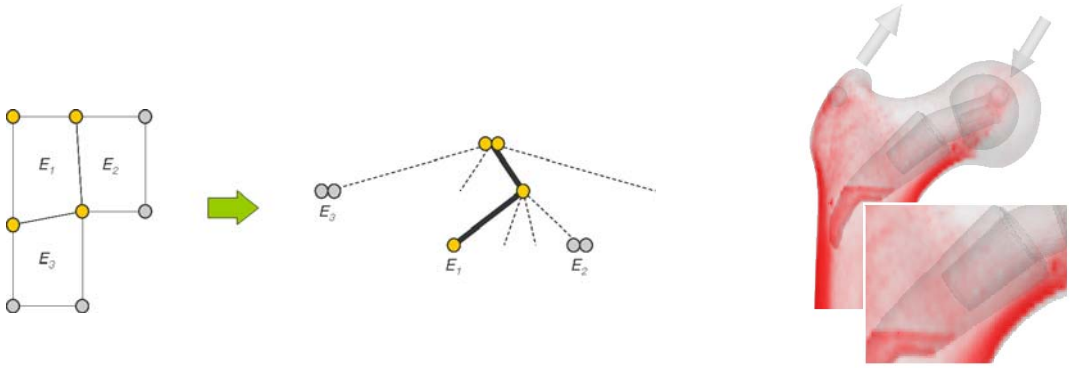

Fig: hierarchical organization of elements, in case of changes due to ND scheme only parts (for instance E_1) have to be recomputed (left); computational orthopaedics for the interactive positioning of implants (right)

In the talk, we will describe our approach using ND along with *p*-FEM in order to reduce the computational effort as well as to exploit parallelisation strategies for the interactive structure simulation of CE applications with the example of computational orthopaedics.