Variational h-adaption for coupled thermo-mechanical problems.

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ABSTRACT

In number of transient problems(mechanical, thermal or thermo-mechanical), zones of high gradients of fields of interest evolve with time and loading. Therefore, it is interesting to have a dynamic mesh adaption algorithm to capture the solution in the zones of high gradients and maintain the required precision.

Many methods of mesh adaption are proposed in the literature based on error-estimation. In these methods, the strategy is to adapt the mesh to minimize an error bound among all meshes of fixed size; or by recursive application of local refinement steps. But, these methods have certain limitations. They work well with linear constitutive models (for example elasticity). But when non-linear constitutive models are used, admissible fields need to constructed, plus an global adjoint problem needs to be solved. In addition, standard error bounds require a certain regularity of the solution for their validity. Therefore, it is very difficult and costly to use this approach for complex problems.

However, variational formulations allow us to express finite element problems as problems of minimization (or maximization) of an energy-like potential. This variational characterization is meaningful regardless of the linear or non-linear structure of the problem and does not presuppose a linear much less normed structure of the space of solution.

An alternative approach of mesh adaption for purely mechanical problems was recently proposed, based on the variational approach of [1]. In variational approach, change in the value of an energy like potential is used as error indicator. No error estimates are used at any stage of the algorithm. It allows mesh adaption in presence of large deformations and non-linear constitutive behaviour. The mesh adaption algorithm relies on the definition of local patches of elements, of which energy-like potential is computed. A refinement procedure is then used for every patch involving at each iteration the assessment of energy-like potential. Once the refinement procedure of all patches has been carried out, a global solution of the problem needs to be computed on the refined mesh.

Steady and transient thermal problems are first considered, on which the algorithm is analyzed for optimized performance. Then coupled thermo-mechanical problems (thermo-elasticity and thermo-elasto-visco-plasticity) are used to show the effectiveness of the approach. In the latter, staggered schemes [2] are used, coupled with the use of different meshes for the thermal and mechanical parts. Two dimensional problems are studied. In order to demonstrate compatibility of the algorithm with different geometric refinement strategies, two geometric refinement strategies have been used: simple edge bisection technique, and RIVARA's technique.

We carry out extensive analysis of the algorithm on each test case and successfully demonstrate the cost effectiveness of the algorithm with respect to using a simple uniform mesh.

REFERENCES

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