Université catholique de Louvain UCL SECTEUR DES SCIENCES ET TECHNOLOGIES

INSTITUTE OF MECHANICS, MATERIALS AND CIVIL ENGINEERING

Invitation à la soutenance publique de thèse

Pour l'obtention du grade de Docteur en Sciences de l'Ingénieur

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Engineering analysis with non conforming meshes and levelsets

Finite element analyses became predominant in engineering offices to simulate the behaviour of parts to design. Yet the bottleneck of the method remains the mesh generation. It accounts for around 80% of the time devoted to the analyses. This can be explained by the fact that the CAD representation of the geometry is not suited for a finite element simulation. It can include overlapping surfaces or volumes and small features unessential for the simulation. Simulations with evolving interfaces are particularly concerned as the geometry has to be remeshed for each step.

In this thesis, we present two new methods that attempt to limit human intervention in the meshing process. Both methods rely on an implicit representation of the geometry. This representation is described by a levelset function, obtained as the signed distance function to the STL triangulation of the boundary of the geometry. An unstructured mesh is then generated in a box surrounding the geometry wherein the boundaries are embedded.

The first method is based on the cutting of the elements crossed by the embedded interface into sub-elements. To integrate PDEs, only the part belonging to the computational domain are taken into account. Yet imposing Dirichlet boundary conditions with Lagrange multipliers on embedded interfaces creates an over-constrained problem that produces instabilities. To remove those instabilities, a Laplace stabilization term is introduced in the formulation. But this term includes a scalar stabilization coefficient that needs to be be calibrated.

The second method is based on local mesh adaptation in the vicinity of the embedded interface to obtain a nearly body-fitted mesh. Anisotropic mesh adaptation is required to obtain the geometrical convergence and limit the increase in the number of elements. The mesh size in the direction normal to the interface is imposed to obtain an optimal rate of convergence. This method is not intrusive, the classical finite element formulation can be used to solve problems.

Finally, both methods are challenged on complex geometries in linear elasticity for validation. Convergence and time of meshing and computation are analysed to compare the methods. Sensitive parameters are needed to perform the computation. This limits the robustness of both methods. Yet we believe that these contributions are a building block for the path towards the full automation of mesh generation.

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