Universität Stuttgart

Baustatik und Baudynamik

Master Thesis

Mixed Displacement Method and NURBS-enhanced Finite Elements

In the Finite Element Method (FEM), the CAD geometry is approximated during the mesh generation process. Isogeometric analysis (IGA) resolves this issue by using the underlying function spaces from the CAD geometry directly for approximating the solution field. However, the CAD software usually only provides a boundary representation (B-rep) of the geometry and not the volume representation (V-rep) required for analysis. NURBS-enhanced Finite Element Method (NEFEM) integrates the B-rep from CAD with a standard FEM mesh to provide an exact discretization of the geometry. Nevertheless, the locking phenomenon hinders the approximation quality when choosing a relatively coarse mesh. The mixed displacement (MD) method was developed to treat geometric locking phenomena on a theoretical level, thereby showing locking-free characteristics irrespective of the discretization scheme.

In this thesis, the MD method ought to be investigated in the context of NEFEM. The standard and MD-based solid elements have to be implemented in the framework FEM and NEFEM. Several benchmark problems have to be assessed to study shear locking characteristics within the framework of linear elasticity. The results from FEM and NEFEM have to be compared using both the standard primal formulation and the MD method. Lastly, a systematic comparative investigation of the quality of the results is required.

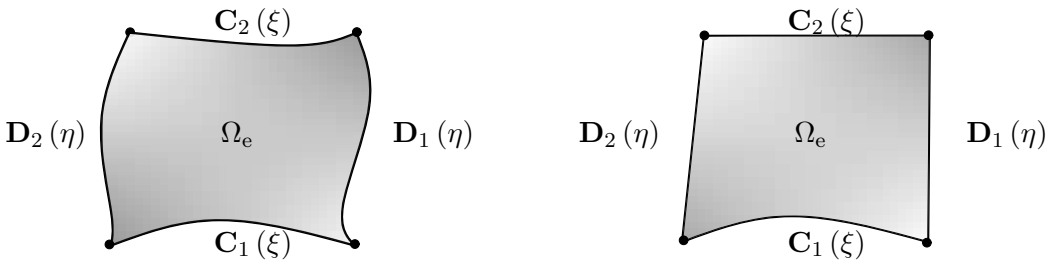

Illustration of the parameterisation of curved NEFEM elements (adapted from [3])

The specific tasks are

- Familiarization with NEFEM and the MD method
- Implementation of standard and MD-based solid elements in the framework of FEM and NEFEM (for example, using Matlab/Python/C++)
- Analyze various benchmark problems with different boundary conditions, loading scenarios, integration points, element shapes (triangles and quadrilaterals), and using both isoparametric and non-isoparametric concepts.

Recommended fields of interest

FEM, IGA, CAD, Locking, Programming

Literatur

[1] Bieber, S., Oesterle, B., Ramm, E., Bischoff, M., 2018. "A variational method to avoid locking - independent of the discretization scheme". Int J Numer Methods Eng 114, 801–827.
[2] Sevilla, R., Fernández-Méndez, S., Huerta, A., 2008. "NURBS-enhanced finite element method (NEFEM)". Int J Numer Methods Eng 76, 56–83.
[3] Montanari, M., Santi, G.M., Sevilla, R., Alfredo, L., Petrinic, N., 2024. "NURBS-enhanced finite element method (NEFEM) on quadrilateral meshes". Finite Elements in Analysis and Design 231