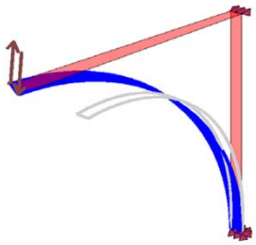
Spatial IsoGeometric Beam Elements

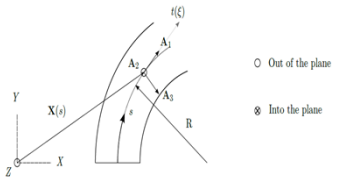
Pradeep Keshavanarayana



Beam bending out of plane

Motivation

- Use CAD geometry for analysis of 3D beams
- Geometrical Locking in spatial beams
- Multi patch formulations



Basis vectors

Solution for the problem

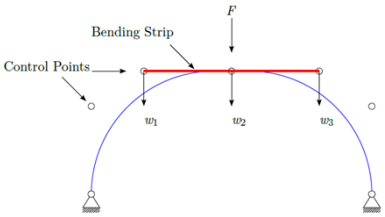
$$\epsilon_t = u_t' - \kappa u_n$$
$$\gamma_n = u_n' + \kappa u_t - \theta_b - u_b\chi$$
$$\gamma_b = u_b' + \theta_n + u_n\chi$$
$$\tau = \theta_t' - \kappa\theta_n$$
$$\kappa_n = \theta_n' + \kappa\theta_t - \theta_b\chi$$
$$\kappa_b = \theta_b' + \theta_n\chi$$

Curved Timoshenko beam

- Higher continuity available with NURBS
- Hierarchic timoshenko for shear locking removal
- Hierarchic Hybrid stress(p3p1) formulations for membrane locking removal

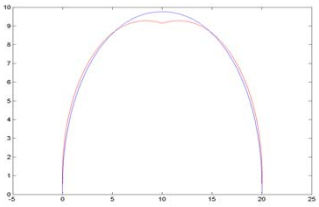
$$\epsilon_t = u_t' - \kappa u_n$$
$$\tau = \kappa u_b' - \kappa\gamma_b + \theta_t'$$
$$\kappa_n = -u_b'' + \kappa\theta_t + \gamma_b'$$
$$\kappa_b = u_n'' + (\kappa u_t)' - \gamma_n'$$
$$\gamma_n = \gamma_n$$
$$\gamma_b = \gamma_b$$

Curved Hierarchic Timoshenko beam



Bending strip method

- Bending strip for connecting patches
- No shear coupling in bending strip
- Lagrange multipliers

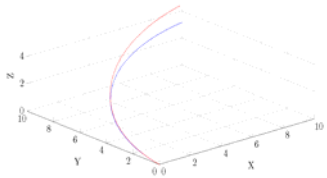


with and without patch connection

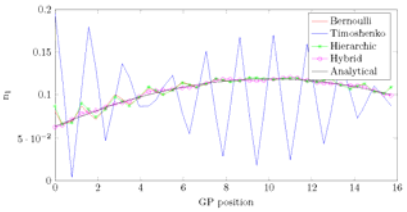
Example

IsoGeometric spatial curved beams

Reference
Displaced

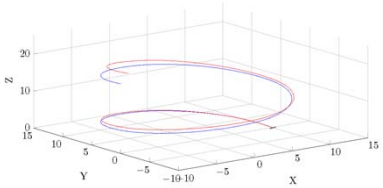


Spatially curved beam



Membrane locking removal

Reference
Displaced



Spring problem

Literature:
- Hughes et.al,2005:Isogeometric Analysis
- Kiendl et.al,2010: The bending strip method for Isogeometric analysis

Institut für Baustatik und Baudynamik
Prof. Dr.-Ing. habil. Manfred Bischoff