UNIVERSITÀ DEGLI STUDI FIRENZE — UNIVERSITÀ DI PISA — Technische Universität Braunschweig

International Doctorate in Civil and Environmental Engineering

DOCTORAL COURSE

Introduction to Isogeometric Analysis (IGA) with applications to shells and nonlinear beams

Teacher: Dr. **Enzo Marino**
DICEA, Università degli Studi di Firenze
enzo.marino@unifi.it

Calendar	
02/03/2021 - 15:00-17:00 (online)	Introduction to B-splines and NURBS basis functions. Curves and surfaces representation
05/03/2021 - 10:00-12:00 (online)	IGA methods for shells
09/03/2021 - 15:00-17:00 (online)	IGA methods for linear and nonlinear beams: statics I
12/03/2021 - 10:00-12:00 (online)	IGA methods for linear and nonlinear beams: statics II
16/03/2021 - 15:00-17:00 (online)	IGA methods for nonlinear beams: dynamics I
19/03/2021 - 10:00-12:00 (online)	IGA methods for nonlinear beams: dynamics II
Total	12 hours – 6 credits

Program

Isogeometric analysis (IGA) is a method for the solution of problems governed by partial differential equations. The method was introduced in 2005 by Hughes et al. [1] with the aim of representing the exact geometry regardless of the mesh refinement level and simplifying the expensive operations of mesh generation and refinement required by traditional Finite Element Analysis (FEA) [2]. This is possible by using the higher-order basis functions adopted in Computer Aided Design (CAD), e.g. NURBS [3], not only to describe the domain geometry, but also to represent the numerical solution of the differential problem. The isogeometric collocation (IGA-C) method [4] is based on the discretization of the strong form of the governing equations and, since there is no need for numerical quadrature, the computational cost is drastically reduced. IGA has become a new paradigm for the solution of a wide range of problems including structural mechanics, turbulent flow and fluid-structure interaction.
This course will give an overview of the main attributes and potentialities of the methods with the focus on structural mechanics. After an introduction to NURBS basis functions, IGA formulations of linear plates and shells (an example is shown in Fig. 1) [5], as well as 3D beams undergoing finite rotations (an example is shown in Fig. 2) [6], will be addressed. Emphasis will be placed on geometrically nonlinear problems, which, due to the presence of finite rotations, require geometrically consistent procedures for the linearization of the strong form of the governing equations, for the configuration updates, and for the time integration of the dynamic problem.

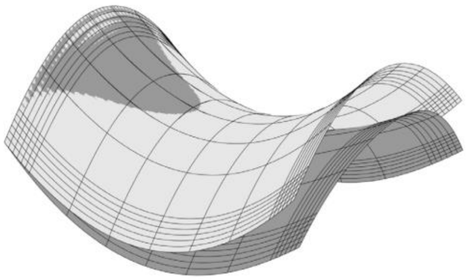

Fig. 1. Linear IGA-C simulation of a partly clamped hyperbolic paraboloid. Undeformed and deformed (dark grey) configurations [5].

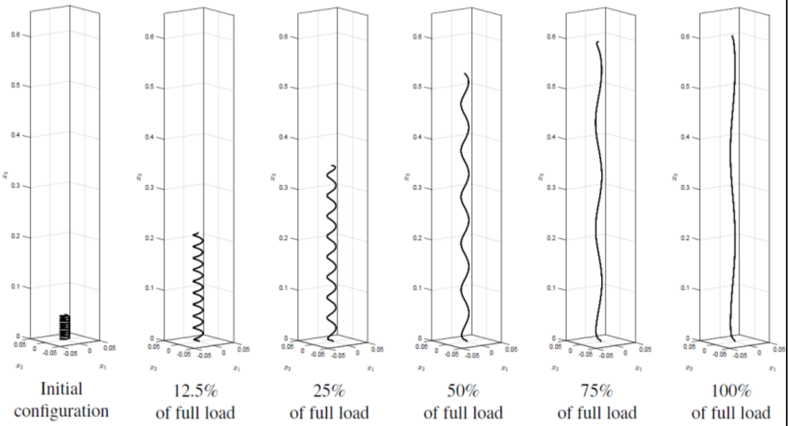

Fig. 2. Nonlinear IGA-C simulation of a helical spring under a pulling load [6].

References

[1] T. J. R. Hughes, J. A. Cottrell, and Y. Bazilevs, "Isogeometric analysis: CAD, finite elements, NURBS, exact geometry and mesh refinement," Comput. Methods Appl. Mech. Eng., vol. 194, no. 39–41, pp. 4135–4195, Oct. 2005.

[2] J. A. Cottrell, T. J. R. Hughes, and Y. Bazilevs, Isogeometric analysis: toward integration of CAD and FEA. John Wiley & Sons, Ltd Registered, 2009.

[3] L. Piegl and W. Tiller, The NURBS Book. Springer, 1997.

[4] F. Auricchio, L. Beirão Da Veiga, T. J. R. Hughes, A. Reali, and G. Sangalli, "Isogeometric Collocation Methods," Math. Model. Methods Appl. Sci., vol. 20, no. 11, pp. 2075–2107, 2010.

[5] J. Kiendl, E. Marino, and L. De Lorenzis, "Isogeometric collocation for the Reissner–Mindlin shell problem," Comput. Methods Appl. Mech. Eng., vol. 325, 2017.

[6] Marino, E., "Locking-free isogeometric collocation formulation for three-dimensional geometrically exact shear-deformable beams with arbitrary initial curvature," Comput. Methods Appl. Mech. Eng., vol. 324, pp. 546–572, 2017.