

**UTAustin | Portugal Short Course on**

## **ISOGEOMETRIC ANALYSIS**

**Instituto Superior Técnico, University of Lisbon  
Portugal**

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### **ABSTRACT**

Last October marked the tenth anniversary of the appearance of the first paper [1] describing a vision of how to address a major problem in Computer Aided Engineering (CAE). The motivation was as follows: Designs are encapsulated in Computer Aided Design (CAD) systems. Simulation is performed in Finite Element Analysis (FEA) programs. FEA requires the conversions of CAD descriptions to analysis-suitable formats from which finite element meshes can be developed. The conversion process involves many steps, is tedious and labor intensive, and is the major bottleneck in the engineering design-through-analysis process, accounting for more than 80% of overall analysis time, which remains an enormous impediment to the efficiency of the overall engineering product development cycle.

The approach taken in [1] was given the name *Isogeometric Analysis*. Since its inception it has become a focus of research within both the fields of FEA and CAD and is rapidly becoming a mainstream analysis methodology and a new paradigm for geometric design [2]. The key concept utilized in the technical approach is the development of a new foundation for FEA, based on rich geometric descriptions originating in CAD, resulting in a single geometric model that serves as a basis for both design and analysis.

In this short course I will introduce Isogeometric Analysis, describe some of the basic tools and methods, identify a few areas of current intense activity, and areas where problems remain open, representing opportunities for future research [3].

### **REFERENCES**

[1] T.J.R. Hughes, J.A. Cottrell and Y. Bazilevs, *Isogeometric Analysis: CAD, Finite Elements, NURBS, Exact Geometry and Mesh Refinement*, Computer Methods in Applied Mechanics and Engineering, 194, (1 October 2005), 4135-4195.

[2] J.A. Cottrell, T.J.R. Hughes and Y. Bazilevs, *Isogeometric Analysis: Toward Integration of CAD and FEA*, Wiley, Chichester, U.K., 2009.

[3] *Isogeometric Analysis Special Issue* (eds. T.J.R. Hughes, J.T. Oden and M. Papadrakakis), *Computer Methods in Applied Mechanics and Engineering*, 284, (1 February 2015), 1-1182.

## OUTLINE

1. Isogeometric Analysis
  - a. Background and brief history
2. B-splines, NURBS
  - a. Linear elasticity
    - i. Approximation theory
  - b. Spectral approximation
    - i. Vibrations
    - ii. Eigenvalue problems
  - c. Nearly-incompressible solids
  - d. Nonlinear solids
  - e. Shells (w/wo rotations)
  - f. Contact
  - g. Collocation
  - h. Reduced quadrature
  - i. Phase-field methods
  - j. Fluids and fluid-structure interaction
3. Analysis-suitable IGA Technologies
4. T-splines and Trimmed NURBS
  - a. Extraordinary points
  - b. Design-through-analysis
    - i. Surfaces
    - ii. Volumes
  - c. Boundary element methods
  - d. Hierarchical B-splines and immersed boundary methods
    - i. Solids
  - e. Phase-field modeling of crack propagation
    - i. Brittle fracture
5. Conclusions and Future Prospects

## SCHEDULE

- 9:00 am to 9:30 am – Registration
- 9:30 am to 11:00 am – Lecture
- 11:00 am to 11:30 pm – Break with light refreshments
- 11:30 am to 1:00 pm – Lecture
- 1:00 pm to 2:30 pm – Lunch
- 2:30 pm to 4:00 pm – Lecture
- 4:00 pm to 4:30 pm – Break with light refreshments
- 4:30 pm to 6:00 pm – Lecture
- 6:00 pm to 7:00 pm – Reception