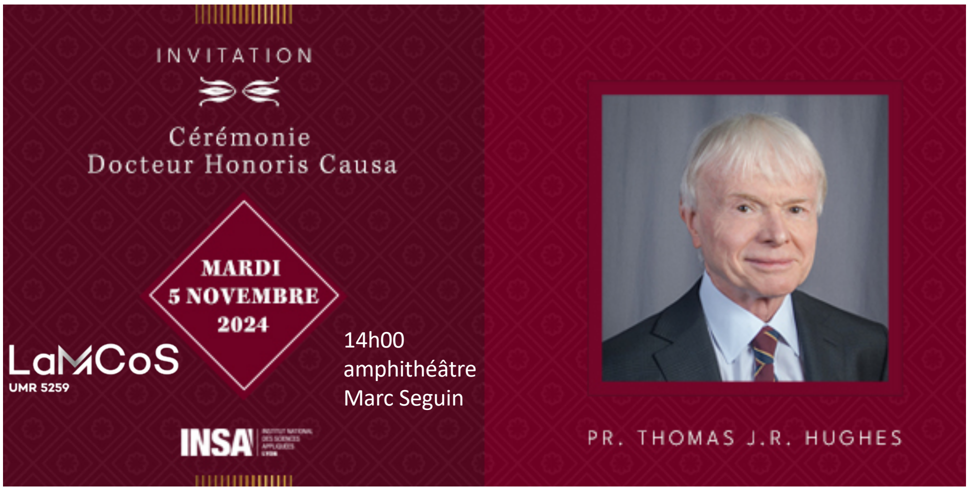

The Finite Element Method and Isogeometric Analysis: Past, Present, Future
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I will begin by probing into the past to discover the origins of the Finite Element Method (FEM), and then trace the evolution of those early developments to the present day in which the FEM is ubiquitous in science, engineering, mathematics, and medicine, and the most important discretization technology in Computational Mechanics.

However, despite its enormous success, there are still problems with contemporary technology, for example, building meshes from Computer Aided Design (CAD) representations is labor intensive, and a significant bottleneck in the design-through-analysis process; the introduction of geometry errors in computational models that arise due to feature removal, geometry clean-up and CAD “healing,” necessary to facilitate mesh generation; the inability of contemporary technology to “close the loop” with design optimization; and the failure of higher-order finite elements to achieve their full promise in industrial applications.

These issues are addressed by Isogeometric Analysis (IGA), the vision of which was first presented in a paper published October 1, 2005 [1]. Since then, IGA has become a focus of research within both FEM and CAD and is now a mainstream analysis methodology that has provided a new paradigm for computational model development [2-4]. 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, more tightly integrating design and analysis. Industrial applications and commercial software developments have expanded recently.

I will briefly present the motivation leading to IGA, its status, recent progress, areas of current activity, and what it offers for analysis model development and the design-through-analysis process. I will also argue that IGA provides an alternative and more robust approach to higher-order finite element analysis, filling the gap between low-order, geometrically versatile approaches and high-order, geometrically restrictive spectral methods. Finally, I will speculate on the future, the technologies that will prevail, computer developments, and the role of machine learning.

[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, (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] Special Issue on Isogeometric Analysis, (eds. T.J.R. Hughes, J.T. Oden and M. Papadrakakis), Computer Methods in Applied Mechanics and Engineering, 284, 1-1182, (1 February 2015).
[4] Special Issue on Isogeometric Analysis: Progress and Challenges, (eds. T.J.R. Hughes, J.T. Oden and M. Papadrakakis), Computer Methods in Applied Mechanics and Engineering, 316, 1-1270, (1 April 2017).