PhD Proposal 2017

School: Ecole Centrale de Marseille	
Laboratory: Laboratoire de Mécanique et d'Acoustique	**Web site: http://www.lma.cnrs-mrs.fr/**
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Collaboration with other partner during this PhD: **In France: -**	**In China: -**

Title: Space-time finite Isogeometric analysis in solid and structure mechanics
Scientific field: Computational mechanics, applied mathematics
Key words: isogeometric analysis, finite elements, space-time formulation, object-oriented, Java, nonlinear mechanics

[1] Put here 1, 2 or 3 email personal addresses, separated by commas, of colleagues who will have access to folder of student candidates on the web site. Do not use generic laboratory addresses.

Details for the subject:

Background, Context:

In mechanical engineering, the simulation of long term processes such as fatigue or ageing may become very heavy in term of computational effort even for rather small problems. In solid mechanics, the finite element method is widely used, typically when addressing nonlinear problems. Usually, finite elements are used in space while finite differences schemes are used in space. The consequence of it is the necessity to have a large number of time steps to achieve large-scale simulations in time. In the 90's, a few approaches have been investigated to apply finite elements discretization in both time and space (see e.g. [1] and [2]). The major advantage of it is to keep simplicity of the code obtained such a way and to have finite elements properties in both space and time. As the solution is computed allover a space-time domain, the number of unknowns of the problem solved on a time-step is much bigger than the one necessary with traditional finite difference schemes in time. But, a new numerical method recently proposed by Hughes in 2005 (see [3]) opens new promising horizons for this kind of original formulation: isogeometric analysis.

Isogeometric analysis is a novel and innovative computational method that aims at integrating the geometric design into the computational model. It is interesting to notice that in an industrial context, the effort put in the design of the computational domain on CAD systems is often very tough. The idea to directly integrate the functions provided by the CAD in the simulation is very attractive. More over, the numerical performances of these formulations are very promising. In the same context, the simulations in mechanical engineering are getting more and more complex. E.g., the problems occurring today in computational mechanics often involve several physics at different time and space scales.

In this work, we propose to develop innovative numerical schemes to handle long term simulations based on space-time formulations and isogeometric analysis in solid and structural mechanics aiming at simplifying global computational strategies. Techniques of model reduction might be investigated in the context of the extension to large scale simulations. In this context, we have been developing for more than 10 years (see [4, 5, 6, 7, 8, 9]) original software solutions aiming at fastening the development of traditional finite element models.

Research subject, work plan:

The first part of this project will aim at investigating space-time formulations and typical discontinuous space-time schemes; the latter is a special case of discontinuous Galerkin formulations. Discontinuous space-time schemes have bee studies in the context of compressible and incompressible flows involving deformable boundaries (see e.g. [13, 14]). Part of this study will consist in extending these schemes to highly deformable medias in solid mechanics (e.g. simulation of viscoelastic and/or visco-elastoplastic media at large strains [11] and see [12] as an example of space-time viscoelastic formulation at small strains). The main idea of this research project is to apply Isogeometric analysis to these methodologies and to investigate techniques of model reduction. The method will be applied in the in the domain of the simulation of aeronautics parts.

Standard knowledge in numerical analysis, in continuum mechanics and software engineering are required (Master level).

References:

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