11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20–25, 2014, Barcelona, Spain

REAL-TIME SIMULATION OF SURGICAL CUTTING USING PGD

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Key words: *Real-time, Surgery, Proper Generalized Decomposition, X-FEM*

Realistic simulation of surgical cuts in soft tissues is a significant source of difficulties in real-time modelling, since it is necessary to modify the geometry and topology of the domain and its associated mesh without penalizing the computation time.

In this work, a method for real-time simulation of surgical cuts in haptic environments is presented. For an accurate haptic modelling some 500 Hz–1 kHz of feedback response is needed. The method here proposed relies on a reduced-order modelling technique, based on the use of separated representations, known as Proper Generalized Decomposition (PGD).

The key idea of this technique is to pre-compute off-line a sort of computational vademecum (a general solution for the parametric, high-dimensional problem) for every possible value of the considered parameters. This vademecum or meta-model is then evaluated on-line at very fast feedback rates. Thus, simulation of highly complex constitutive models is achieved, at real-time feedback rates, simply by accessing the stored high-dimensional solution.

As a novelty, surgical cutting is simulated by the combination of PGD with X-FEM techniques. An appropriate PGD–X-FEM coupling is designed that allows obtaining kHz feedback rates in the simulation of surgical cutting regardless of the constitutive modelling of soft tissues. Examples will be given on the performance of the technique.