Prosthesis optimization using contact formulation in the Cartesian Grid Finite Element Method (*cgFEM*) framework

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ABSTRACT

Numerical simulations techniques are widely spread and are used to model a huge variety of physical phenomena. By using these computational models the experimental test to develop new products is drastically reduced, specially structural components in the fields of mechanical and civil engineering. The most extended technique used in these fields is the Finite Element Method (FEM). However, *cgFEM* [1] tries to improve the computational efficiency of standard FEM by using cartesian meshes independent from the geometry. Additionally, *cgFEM* generates finite element models obtained directly from medical images, allowing agile patient-specific simulations. Along with the implementation of a contact formulation [2], we are able to characterize the bone-prosthesis behavior, among other possibilities. The improvement in efficiency due the use of *cgFEM* allows to consider more computational consuming problems such as topology optimization.

Topology optimization algorithms, such as the SIMP method [4], modify the design of a given component to minimize an objective function, subjected to a set of constraints. Usually, in structural optimization, the objective function is the strain energy or the mass (i.e. the volume) of the component. Regarding bio-mechanical components optimization, the common objective functions are not that significant. Scientist and doctors search for stability of the prosthesis in time. One of the main issues related to prosthesis stability is the stress shielding effect [3]. In this work, we try to investigate a design method for prosthesis that allows to obtain optimized models from the structural and functional point of view, minimizing the risk of aseptic rejection.

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