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# Finite element modeling of interactions between pelvic organs due to pressure

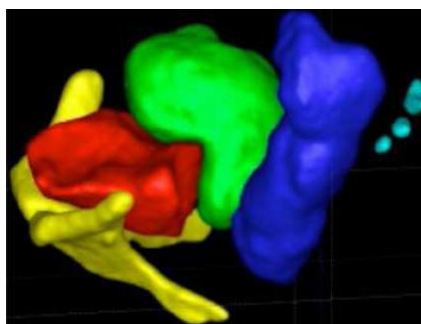
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## Abstract

Pelvic floor (pelvic support) disorders occur only in women and become more common as women age. They involve a dropping down (prolapse) of the bladder, urethra, small intestine, rectum, uterus, or vagina caused by the failure of the system of support. About 11.1% of women need surgery for a pelvic floor disorder during her lifetime, given an average life expectancy is 79 years [1], which brings out the importance of the objective of this study.

Our project is to conceive a simulator of soft tissues based on physical behaviours of each organ taking into account interactions between them inside the pelvic cavity. This simulator will be in a loop of a clinical routine to provide preoperative information for the surgery planning. In this workflow, the simulation will be based on a patient-specific in which each geometrical model will be carried out starting from MRI acquisition of pelvic organs of one patient as shown in Figure 1 [2]. The constraint time simulation has to be considered and fast computational methods are necessary to solve large deformations with multiple contacts.



**Figure 1.** *Geometrical models of pelvic organs*

However there is an ongoing quest for realistic visual deformation of soft tissues and it is important to consider the different kinds of soft tissue constitutive laws. To determine the strain and stress in the biological soft tissues hyperelastic constitutive laws are often used in the context of finite element analysis.

In case of isotropic behaviour, the Mooney-Rivlin model, described by the strain energy density function (1), is often chosen in the literature [3]. This model has been implemented into an in-house finite element code FER [4, 5] to model the bladder, the rectum and the uterus.

$$W = C_{10}(I_1 - 3) + C_{01}(I_2 - 3) + \frac{1}{d}(J - 1)^2 \quad (1)$$

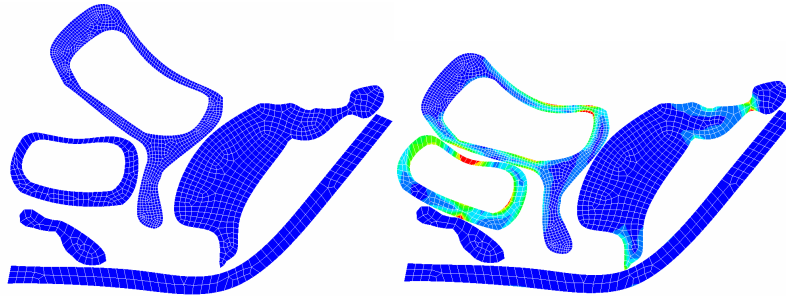
where  $C_{10}$ ,  $C_{01}$  and  $d$  are the material coefficients.  $I_1$  and  $I_2$  are the first and second invariants, respectively.

Most energy densities used to model transversely isotropic and orthotropic soft tissues take a power law form [6] or present an exponential form [7, 8]. We have implemented the Gasser-Ogden-Holzapfel constitutive law to model ligaments which carry pelvic organs.

From a mechanical point of view, the pelvic organs move and interact with each other, due to the external and internal organ loadings, which are very cumbersome to estimate, in the present study, compressive pressure is considered.

The contact forces between pelvic organs is modelled by the bi-potential method [9] and computed by Uzawa or Newton techniques which lead to an iterative predictor/corrector process.

In the first period of this work, we have chosen the sagittal cross-section of the three-dimensional model, so a two-dimensional model has been considered. The finite element mesh of the initial step and the Von Mises stress distribution in the last step are shown in figure 2.



**Figure 2.** *Interactions between pelvic organs.*

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