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DATA DRIVEN SURGICAL SIMULATIONS

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Surgery is a life saver, but too many incidents may occur due to difficult unmastered techniques. It is important to train performants and skilled surgeons to be prepared to handle any pathology, so computer simulation has acquired a great importance in recent years. Finite-Element based Surgical simulation, pioneered by S. Cotin [1] has played a dominant role in helping surgeons hone their skills. The main difficulty in surgical simulation is that the amount of patient-specific data available on a given patient is limited. Mechanical information, which could lead to the identification of mechanical models and stiffness parameters is particularly scarce. This lack of data makes choosing models and parameters a serious challenge in patient-specific surgical simulation. When simulating soft tissue responses during surgery, the mathematical model representation of reality is imprecise, for four main reasons:

(1) choice and uncertainties of the model
(2) choice and uncertainties of the parameters
(3) description of the geometry of the organ
(4) description of the boundary conditions

Kalman filters were shown to be suitable for surgical and interventional radiology guidance [2] and are helpful in improving the simulation of such uncertain systems. The central point of Kalman filters is to estimate the state of a process by combining (noisy) physics-based solutions and (noisy) measurement data, which is acquired on fly [3]. In this work, at first different variants of Kalman filters are implemented for simple mechanical systems to explain their effectiveness for simultaneous state and parameter estimation. In later part, Unscented Kalman filters are implemented for predicting non-linear responses which usually arise in hyper-elastic soft tissue systems. For all the cases, normally distributed synthetic measurement data is created around the ideal solution, which will be eventually replaced with real data. Thus, we set a new effective framework to improve conventional finite element solvers by incorporating measurements thereby increasing the simulation accuracy.

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