AbstractID: 3108 Title: The Effect of Heterogeneous and Nonlinear Material Properties on Organ Deformation

Purpose: The purpose of this research is to investigate the effect of intra-organ heterogeneous material properties on finite element model (FEM)- based deformable image registration.

Method and Materials: Heterogeneities were included in the organ of interest, the liver for this initial study, in two ways: 1) by randomly distributing spheres of varying size (diameter: 0.5 – 1.5 cm) and number (19 – 79) throughout the liver and 2) by creating a single sub-volume of varying volume ratio (23 – 92%) by contracting the liver contour by varying amounts. A large number of simulation parameters were investigated, including Poisson's ratio (ν = 0.2 – 0.499), elastic modulus (E = 1 – 100 kPa), and hyperelastic properties (0.1 – 660% variations corresponding to 1 – 100 kPa) for varying volume ratios (3 – 92%) of the heterogeneous volume. The Taguchi method was used to investigate the contribution of each parameter to the average difference between the deformations of heterogeneous liver and those of the reference homogeneous liver.

Results: The contributions of Poisson's ratio of the liver and heterogeneous volume sharply decreased and exponentially increased, respectively, as a function of the volume ratio of heterogeneous volume. The maximum contribution (20 – 51%) of the elastic modulus of heterogeneous volume was exhibited at the volume ratio of 54 to 67%. The result also indicates that the maximum average differences and 3-σ differences ranged from 1.2 to 2.4 mm (percent contribution: 28 – 55%) and 1.75 to 4.2 mm (percent contribution: 42 – 97%), respectively.

Conclusion: This study indicates that the variations of the deformation by the material uncertainties are not negligible, but this parametric approach can be applied to extract the quantitative effects of the significant material parameters on the deformation of a heterogeneous liver having various material uncertainties.

Conflict of Interest: Research supported in part by a grant from Varian Medical Systems