AbstractID: 9177 Title: Evaluation of Bayesian Methods for Estimation of Organ Motion and Patient Setup Variation

Purpose: In adaptive radiation therapy, organ motion and patient setup can be measured and parameterized during treatment to refine the therapy. Bayesian statistics has previously been suggested to decrease the parameter estimate uncertainty by combining knowledge about population statistics with patient measurements. Our objective is to quantify the gain in using Bayesian statistics.
Method and Materials: Analytical expressions were derived for two estimators of patient specific systematic and random error: SE, sample estimators based on only patient measurements and BE, Bayesian estimators based on patient measurements combined with population statistics. Analytical expressions were derived for the mean-squared-errors (MSE) for these estimators. These theoretical results were compared to results obtained from a data set of actual prostate positions for 15 patients, acquired in 42 fractions.
Results: BE are in a mean square sense always better compared to SE. For the systematic error, the MSE ratio between SE and BE is $1+\sigma^2/(n\Sigma^2)$ where n is the number of fractions, Σ the standard deviation (SD) of the systematic error and σ the SD of the random error. This means that for a typical prostate case with $\sigma/\Sigma=1$ and n=5, the RMS (root mean square) reduction using BE is 9%. The improvement in estimating the random error is in generally much larger. The MSE ratio between SE and BE is $1+ (2(\sigma^2/\Lambda)^2+3)/(n-1)$ where Λ is the SD of σ^2, which means that for a case with $\sigma^2/\Lambda=1$ and n=5 the RMS reduction is 33%. Experimental data confirms the qualitative content of the theoretical analysis.
Conclusion: By combining measurements of geometrical changes in patient anatomy with population data more robust estimates of organ motion can be obtained. These estimates constitute a more reliable basis for adaptive replanning, for example through individualized PTV design.

Conflict of Interest: Research sponsored by RaySearch Laboratories AB.