Purpose:Large day-to-day variations in bladder–filling hamper accurate radiotherapy of bladder cancer. To allow accurate ART for bladder cancer, automatic bladder segmentation in CBCT is required. However, image quality limitations make this a challenging task. Our aim is to develop an automatic bladder segmentation method using spherical harmonics.

Methods:The method includes two steps: a statistical bladder model was built from training dataset (98 bladder contours from 8 patients) and this model was then applied to automatic bladder segmentation in an independent test dataset (110 CBCT scans from another 7 patients). 3D bladder contours were converted into parametric surface descriptions using spherical harmonic expansion. Principle component analysis (PCA) was applied in the spherical harmonic based shape parameter space to calculate the major variations of bladder shape. The number of PCA modes was chosen such that 90% variation in the training dataset was described. By changing the weight of each PCA mode, an initial contour (from the first CBCT of each patient) was deformed to obtain the best fit with the bladder edge in test image. The fit was achieved by optimizing a cost function based on the image gradient using a simplex optimizer.

Results:Only 5 PCA modes were needed to represent 90% of the bladder shape variation. The mean and SD of the absolute residual error over all test dataset were 4.8mm and 3.5mm, respectively. The mean volume overlap was 76%. The agreement of plan selection between automatic and manual bladder segmentation was 71%, which was similar to human observer.

Conclusions:PCA on spherical harmonics space efficiently describes bladder deformation. This segmentation approach is robust to relatively poor CBCT image quality and allows fast and automatic segmentation of bladder on CBCT with moderate accuracy. This method can potentially be used to select the appropriate plan for online ART of bladder cancer.