Semi-automatic segmentation of the prostate midgland in magnetic resonance images using shape and local appearance similarity analysis

We developed and evaluated an algorithm for semi-automated segmentation of the prostatic midgland on T2W MRI. Our method is described at a high level in Fig. 1.

![Algorithm block diagram](image)

**Fig. 1: Algorithm block diagram** illustrating the training the segmentation phases of our method. The blue contour is a manually-delineated boundary. The red points are border delineation output, and the green contour is the corrected border after shape regularization.

**Training**

We measured and characterized the inter-subject consistency of local prostate midgland boundary appearance in T2W MRI acquired using an ER coil, as follows:

1. **Establishing inter-subject boundary point correspondence**: We manually defined 6 corresponding points on each border and arc-length interpolated to obtain 36 points in total.
2. **Calculation of mean local appearance**: We defined a circular image “patch” centered on each of the 36 points in a set of training images. We calculated the mean intensity of each corresponding set of patch pixels, yielding one “mean intensity patch” (e.g. within the circles in Fig. 2) at each of the 36 points.
3. **Calculation of observed shape variability**: We computed a single PDM [1] for all prostate shapes in the training set using the corresponding homologous points.

**Segmentation**

For each test image, the user selected two points: one at the prostate centre and one on the anterior side, defining a line through the pubic symphysis. We used these points to define 36 homologous rays emanating from the centre point. We used a radial-based-search strategy and translated each mean patch along the corresponding ray and computed the normalized cross-correlation (NCC) at each point (Fig. 2). We chose the point with the highest NCC along each ray. This process yielded 36 points intended to define the prostate border. We calculated the parameters of the PDM best fitting the 36 points to generate regularized boundary points from the PDM. By interpolating the points with a spline, we obtained a continuous boundary.
Results
The segmentation results were evaluated by calculating the mean absolute boundary distance (MAD) and Dice similarity coefficient (DSC) to compare the algorithm’s segmentation to manual delineations performed by one operator. We measured a mean±std MAD of 1.6±1.0 mm, and DSC of 89±6% between the semi-automatically segmented contours and the manually-delineated reference standard. Previous work on midgland segmentation of T2W MRI acquired with an ER coil includes that of Artan et al. [2] (DSC of 86±5%), Martin et al. [3] (MAD of 2.4±1.3 mm), Toth et al. [4] (MAD of 89±5%). To the best of our knowledge, our work represents the first time that complementary boundary-based (MAD) and region-based (DSC) segmentation metrics have been used together to evaluate a segmentation algorithm for the prostatic midgland on T2W MRI acquired with an ER coil. Fig. 2 shows two sample results of the segmentation algorithm and Fig. 3 shows the histogram of MAD and DSC for 33 test images.

Fig. 2: (Left) Border delineation. 36 rays and patch translation along one sample ray. A manual segmentation is overlaid in blue for reference but is not provided to the segmentation algorithm. (Middle, Right) Results Patch radius = 17 mm. Red markers show the selected points based on local appearance similarity. The green contour is extracted boundary after applying shape model and interpolation. The blue contour is the manually-delineated boundary.

Fig. 3: a) MAD and b) DSC histograms (33 images).

References: