COMPUTER ASSISTED TREATMENT OF THE PROSTATE

Quadrature phase-based statistical shape and appearance model for prostate segmentation

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Purpose
Prostate volume estimation from segmented prostate contours in Trans Rectal Ultrasound (TRUS) images aids in the diagnosis and treatment of prostate diseases, including prostate cancer. Computer aided semiautomatic or automatic, accurate and computationally efficient segmentation of the prostate in TRUS images is a challenging task, owing to low signal to noise ratio, speckle noise, microcalcifications and heterogeneous intensity distribution inside the prostate region.

Methods
We propose to use texture features in a parametric deformable statistical model of shape and appearance in a multi-resolution framework to segment the prostate. Local phase information of log-Gabor quadrature filter [1] extracts texture of the prostate region in TRUS images. Large bandwidth of log-Gabor filter ensures easy estimation of local orientations and zero response for a constant signal provides invariance to gray level shift. This aids in enhanced representation of the underlying texture information of the prostate unaffected by speckle noise and imaging artifacts. The parametric model of the propagating contour is derived from principal component analysis of prior shape and texture information of the prostate from the training data. The parameters are then modified with the prior knowledge of the optimization space to achieve segmentation. The proposed method closely follows the Active Appearance Model (AAM) proposed by Cootes et al. [2]. However, deviating from their approach of using intensity to build texture space, we use local phase information to make the model robust to large scale contrast variations. The schema of the proposed method is given in Fig. 1.

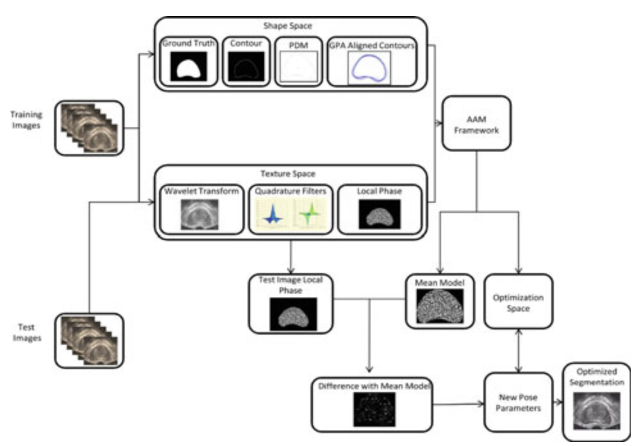

Fig. 1 Schematic representation of our approach. The final segmentation is given in *black* contour and ground truth in *white*. *AAM* active appearance model, *PDM* point distribution model, *GPA* generalized procrustes analysis

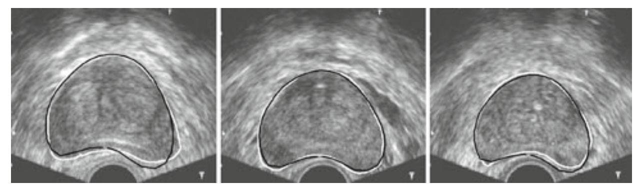

Fig. 2 Qualitative segmentation results of 3 images from 3 datasets. The final segmentation is given in *black* contour and ground truth in *white*

Results
We have validated our method with 24 TRUS images of 6 datasets of prostate in leave-one-patient-out validation framework. Quantitative results are enlisted in Table 1 and some of segmentation results are given in Fig. 2 to have a qualitative estimate of the performance of our approach. We have compared our results with AAM [2]. From Table 1 we observe that introducing local phase information in building the texture model improves segmentation accuracy.

Conclusion
Our method performs accurate prostate segmentations in presence of intensity heterogeneities and imaging artifacts.

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References
[1] Boukerroui, D., Noble, J.A., Brady, M.: On the Choice of Band-Pass Quadrature Filters. Journal of Mathematical Imaging and Vision 21, 23–80 (2004).

Table 1 Quantitative results of our method

	DSC	HD	MAD	MaxD	Specificity	Sensitivity	Accuracy
AAM [2]	0.94 ± 0.03	4.92 ± 0.96	2.15 ± 0.94	5.3 ± 0.48	0.89 ± 0.03	0.99 ± 0.01	0.97 ± 0.01
Our method	0.95 ± 0.03	3.82 ± 0.88	1.26 ± 0.51	3.92 ± 0.93	0.94 ± 0.03	0.98 ± 0.01	0.97 ± 0.01

[2] Cootes, T., Edwards, G., Taylor, C.: Active Appearance Models. Book Series Lecture Notes in Computer Science Springer 1407, 484–498 (1998).