Normalization of T2W-MRI Prostate Images using Rician a priori

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Introduction

- Prostate Cancer (CaP) has been reported the **second** most frequently diagnosed cancer of men accounting for 13.6% [F+10].
- Computer-Aided Diagnosis systems have been proposed in order to assist the radiologists and generally consist of four stages: (i) **pre-processing**, (ii) *segmentation*, (iii) *registration*, and (iv) *classification* [L+15].
- **Normalization** is crucial to overcome the *inter-patient* intensity variations, enforce the *repeatability*, and achieve a *robust* classification.

State-of-the-art method

- Artan *et al.* [A+10] and Ozer *et al.* [O+10] used the **z**-*score* (see Eq. (1)) to normalize T2W-MRI.
- Lv *et al.* [L+09] and Viswanath *et al.* [V+12] used methods based on piecewise-linear normalization [Nea00].

Contributions

We proposed two alternative methods:

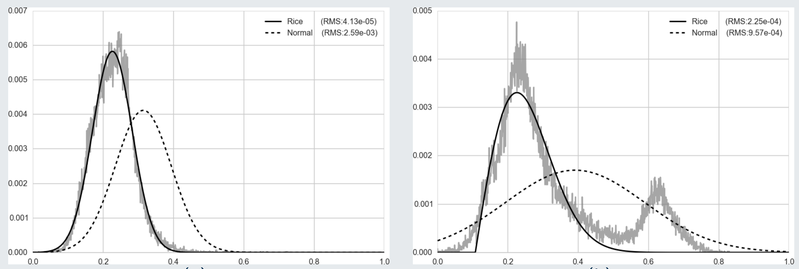
(i) a *model-based* approach using Rician *a priori*;

(ii) a *non-parametric based* approach based on the Square-Root Slope Function (SRSF) representation [SKJJ11].

Model-based normalization

Gaussian normalization

Rician normalization



(a) (b)

Figure : Visual evaluation of the goodness of fitting using Rician and Gaussian distribution.

$$I_s(x) = \frac{I_r(x) - \mu_G}{\sigma_G}. \quad (1)$$

$$I_s(x) = \frac{I_r(x) - \mu_R}{\sigma_R}, \quad (2)$$

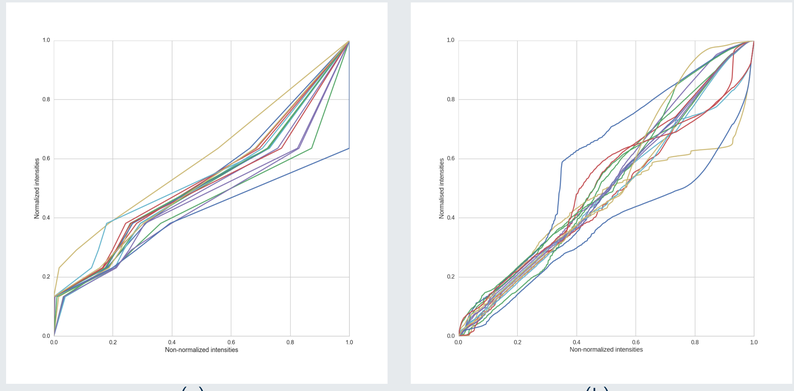
$$\mu_R = \sigma\sqrt{\frac{\pi}{2}}\, L_{1/2}\left(-\frac{\nu^2}{2\sigma^2}\right), \quad (3)$$

$$\sigma_R = 2\sigma^2 + \nu^2 - \frac{\pi\sigma^2}{2} L_{1/2}^2\left(\frac{-\nu^2}{2\sigma^2}\right). \quad (4)$$

Non-parametric normalization

Piecewise-linear normalization

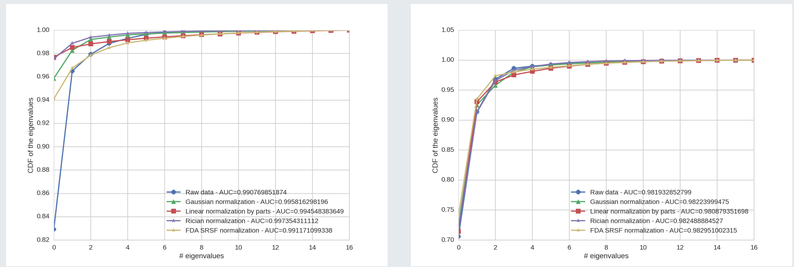
SRSF-based normalization



(a) (b)

Figure : Comparison of warping function obtained with (a) piecewise-linear normalization and (b) SRSF-based normalization.

Quantitative results



(a) (b)

Figure : Spectral evaluation using PCA decomposition: (a) evaluation considering the full prostate, (b) evaluation considering only the CaP.

- Rician normalization outperforms the other methods: Area Under this Curve of **0.9974** and **0.9824** considering the full prostate and CaP, respectively.

Qualitative results

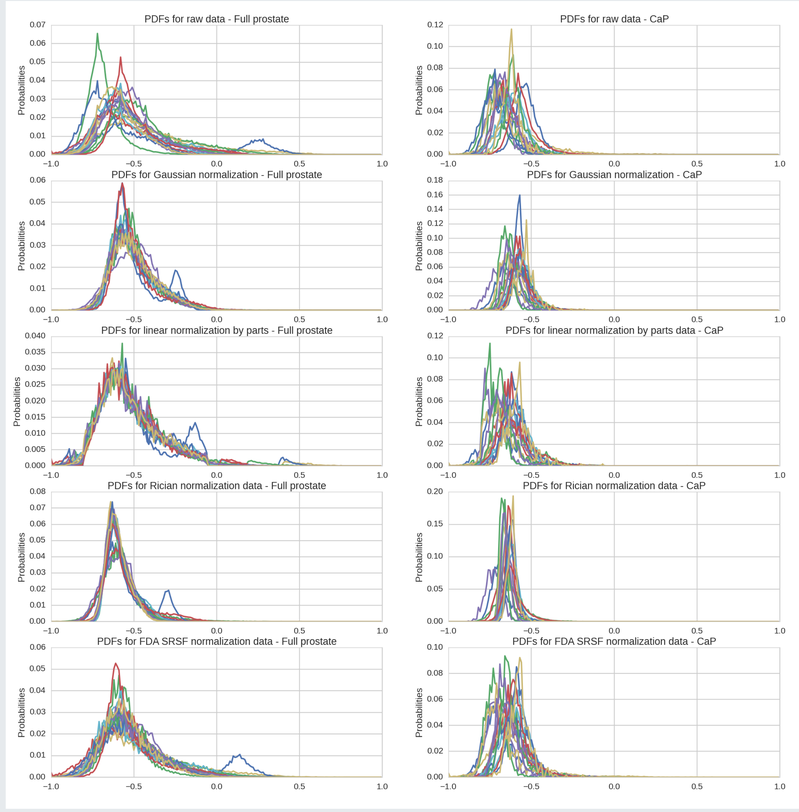


Figure : Qualitative evaluation by visual inspection of the alignment of the PDFs for the full prostate and the CaP.

- All the methods address the problem of the PDF alignment of the full prostate data.
- However, the Rician normalization outperforms the other methods when focusing solely on the CaP data.

Conclusion

Comparisons show that the Rician normalization outperforms the Gaussian, SRSF-based, and piecewise-linear normalization for T2W-MRI prostate images normalization.

References

[A+10] Yusuf Artan et al., *Prostate cancer localization with multispectral mri using cost-sensitive support vector machines and conditional random fields*, IEEE TIP **19** (2010), no. 9, 2444–2455.

[F+10] Jacques Ferlay et al., *Estimates of worldwide burden of cancer in 2008: Globocan 2008*, Int. journal of cancer **127** (2010), no. 12, 2893–2917.

[L+09] Dongjiao Lv et al., *Computerized characterization of prostate cancer by fractal analysis in mr images*, JMRI **30** (2009), no. 1, 161–168.

[L+15] Guillaume Lemaître et al., *Computer-aided detection and diagnosis for prostate cancer based on mono and multi-parametric mri: A review*, Comp. in Bio. Med. **60** (2015), 8 – 31.

[Nea00] László G Nyúl and et al., *New variants of a method of mri scale standardization*, IEEE TMI **19** (2000), no. 2, 143–150.

[O+10] Sedat Ozer et al., *Supervised and unsupervised methods for prostate cancer segmentation with multispectral mri*, Med. Phy. **37** (2010), no. 4, 1873–1883.

[SKJJ11] A. Srivastava, E. Klassen, S.H. Joshi, and I.H. Jermyn, *Shape analysis of elastic curves in euclidean spaces*, Pattern Analysis and Machine Intelligence, IEEE Transactions on **33** (2011), no. 7, 1415–1428.

[V+12] S. Viswanath et al., *Central gland and peripheral zone prostate tumors have significantly different quantitative imaging signatures on 3 tesla endorectal, in vivo t2-weighted mr imagery*, JMRI **36** (2012), no. 1, 213–224.

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