

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:

- a *model-based* approach using Rician *a priori*;
- a *non-parametric based* approach based on the Square-Root Slope Function (SRSF) representation [SKJJ11].

Model-based normalization

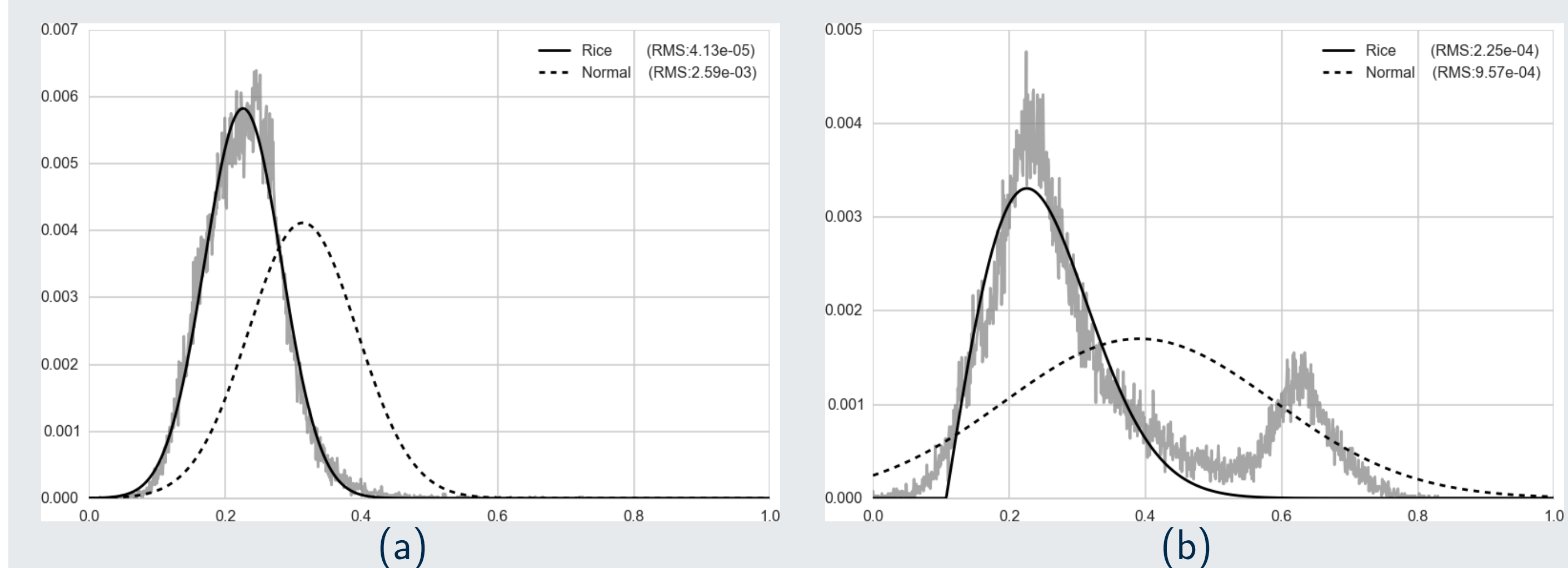


Figure 1 : Visual evaluation of the goodness of fitting using Rician and Gaussian distribution.

Gaussian normalization

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

where,

Rician normalization

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

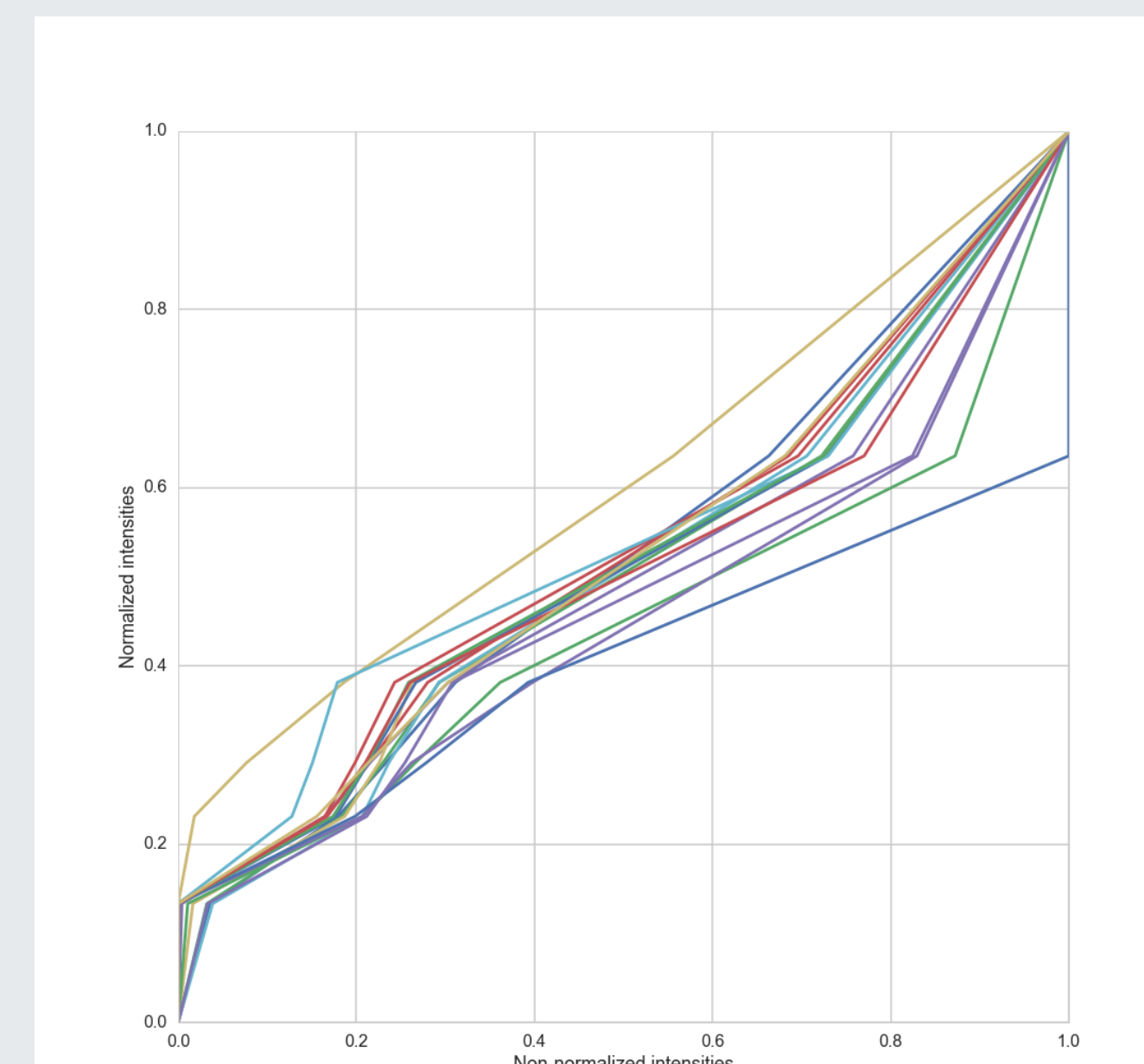
$$\mu_R = \sigma \sqrt{\frac{\pi}{2}} L_{1/2}\left(-\frac{\nu^2}{2\sigma^2}\right), \quad (3)$$

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

- MRI data theoretically follows a Rayleigh distribution for a low SNR scenarios while it appears closer to a Gaussian distribution when the SNR increases [Bea89].
- The Rician model better fits the data than the Gaussian model in terms of RMS.

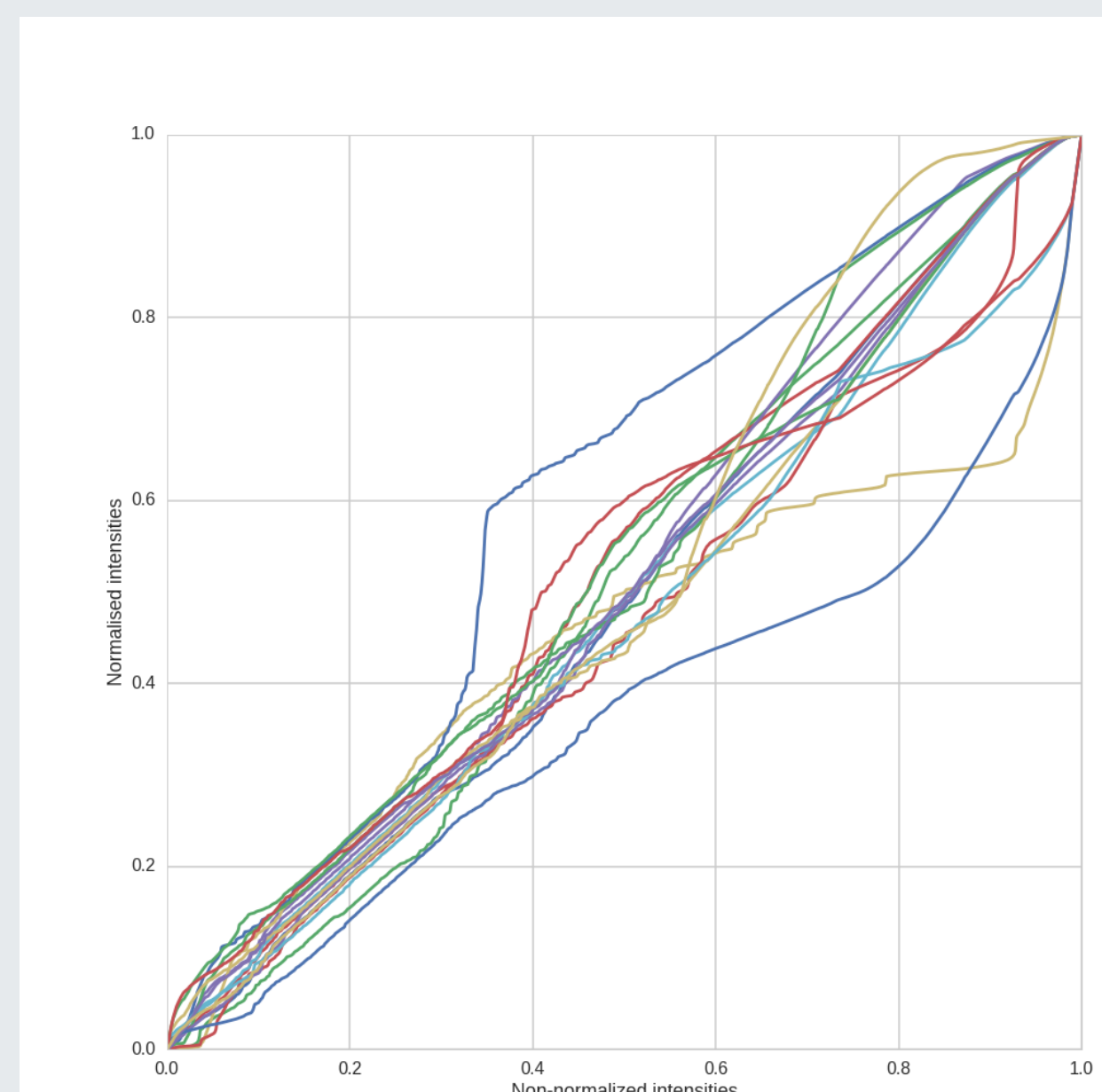
Non-parametric normalization

Piecewise-linear normalization



(a)

SRSF-based normalization



(b)

Figure 2 : Comparison of warping function obtained with (a) piecewise-linear normalization and (b) SRSF-based normalization.

- Minimize the distance between a set of standardized landmarks μ_i (i.e., atlas) and a set of non-normalized landmarks λ_i .
- Minimize the distance between a mean PDF μ_f (i.e., the Karcher mean) and a given patient PDF f_i .
- SRSF-based normalization lead to smoother transition than piecewise-linear normalization.

T2W-MRI prostate dataset

- 3 Tesla whole body MRI scanner.
- 17 patients manually segmented by experienced radiologist.
- Publicly available at <http://visor.udg.edu/i2cvb/>.

Quantitative results

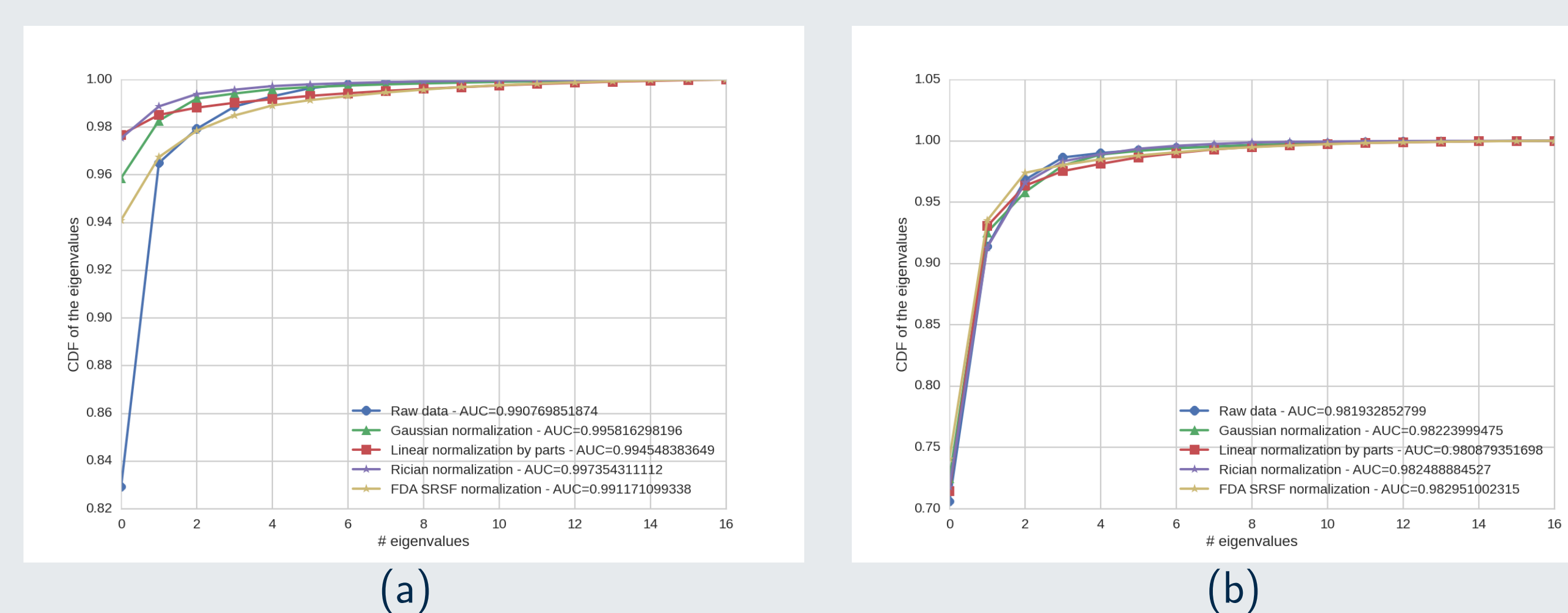


Figure 3 : Eigenvalue decomposition to evaluate the alignment of the PDFs: (a) evaluation considering the full prostate, (b) evaluation considering only the CaP.

- 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

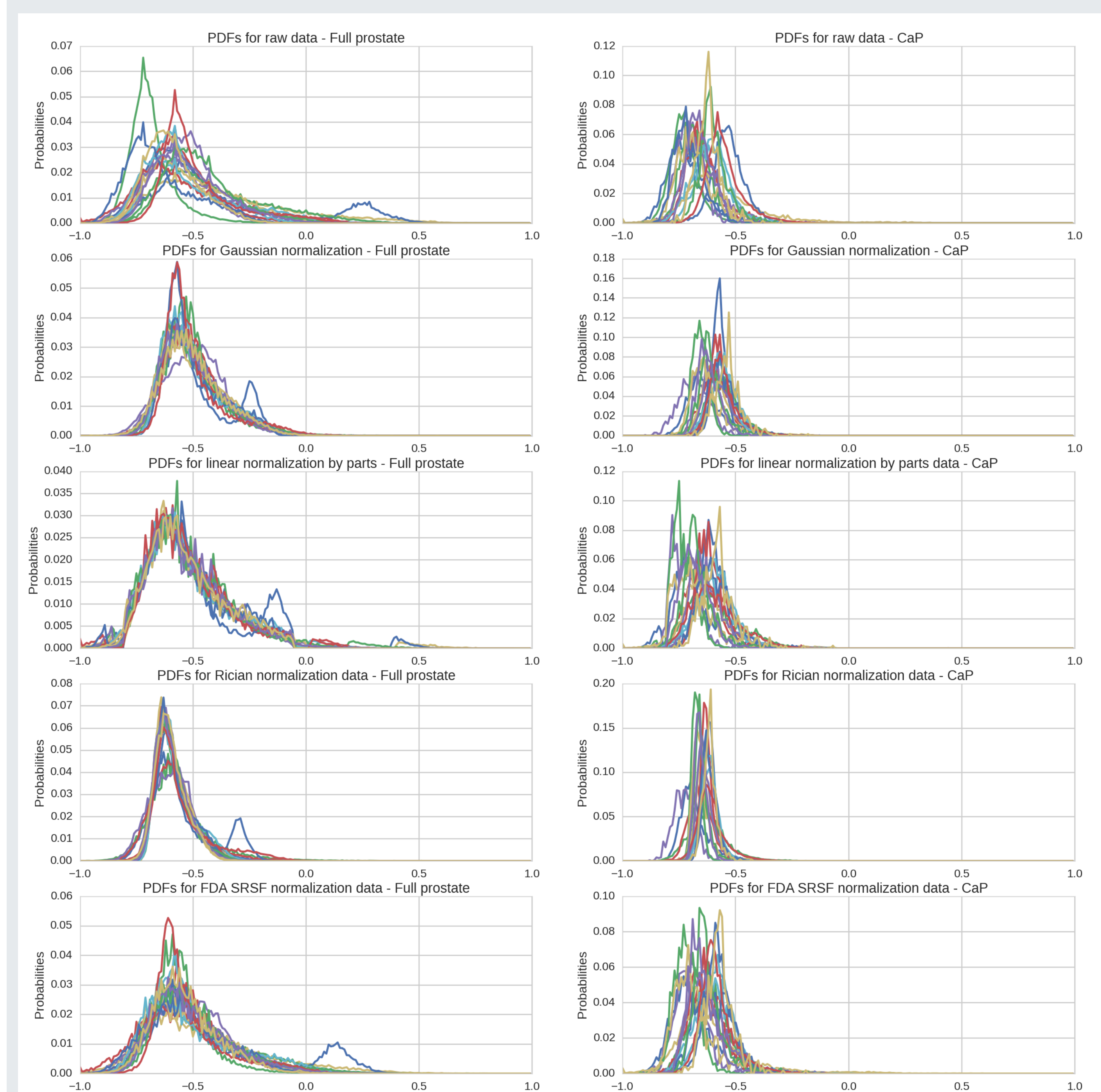


Figure 4 : Qualitative evaluation by visual inspection of the alignment of the PDFs for the full prostate and the CaP.

- 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

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