Stage M2 creatis
Joint Despeckling Deconvolution

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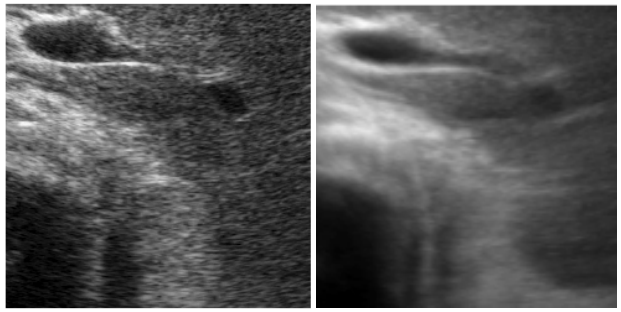
CONTEXT

ultrasound liver image

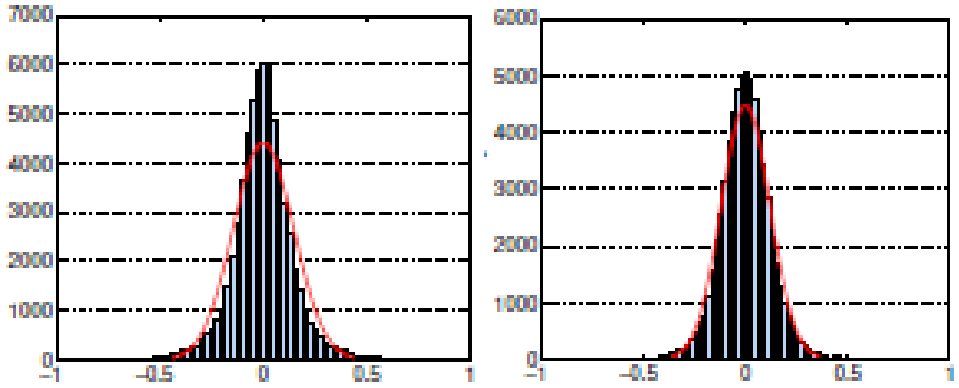


Original Image Time averaged

HWT motivation

- Clinical ultrasound images: speckle noise and blur
- Enhancing these images can:
  - help the practitioners for a better interpretation
  - be a pre-processing step for further tasks such as segmentation and registration
- Noise model: $v = u + u^{\gamma}\varepsilon \qquad \varepsilon \sim \mathcal{N}(0, \sigma^2) \qquad \gamma > 0$
- Hyperbolic wavelet transform (HWT)
- Noise variance stabilization
  - Universal threshold
    $t(\sigma) = \sigma\{2\log(N^2)\}^{1/2}$
    for NxN image

Coefficients distribution



Raw Stabilized

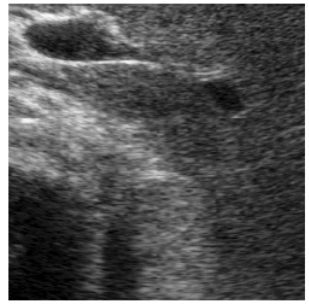
CONTEXT

- Recently, we proposed two methods which aims at removing speckle from US images.
  - wavelet-fisz (WF) despeckling [1]
  - Kronecker Wavelet-Fisz (KWF) dynamic despeckling [2]
- Advantage: competitive with state-of-the-art methods, enjoys adaptability and easy-tuning
- Drawback: the obtained images (cf. Figure) are often still blurred.

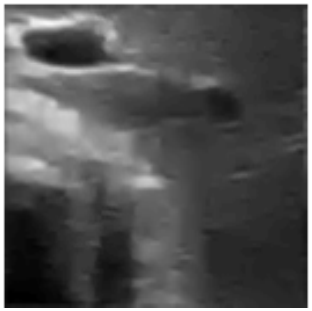
[1] Y. Farouj, J.M. Freyermuth, L. Navarro, M. Clausel, P. Delachartre, Hyperbolic Wavelet-Fisz denoising for a model arising in Ultrasound Imaging. *IEEE Trans. Comp. Imag. (2017)*

[2] Y. Farouj, L. Navarro, M. Clausel, P. Delachartre, Ultrasound Spatio-temporal Despeckling via Kronecker Wavelet-Fisz Thresholding. *Elseiver, Signal Imag. Vid. Processing (In revision)*

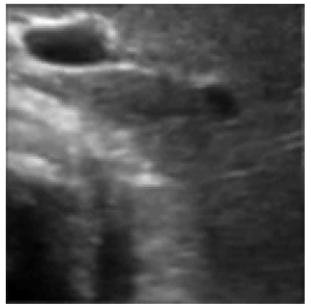
ultrasound liver image



Original Image



Denoised Image (WF)



Denoised Image (KWF)

OBJECTIVE

- The purpose of this internship is to extend WF to perform jointly speckle removal and deconvolution.

- $Model$: $v = K * u + u^{\gamma}\varepsilon \qquad \varepsilon \sim \mathcal{N}(0, \sigma^2) \quad \gamma > 0,$

  where K is a spatially varying PSF.

- Find u from the knowledge of K.

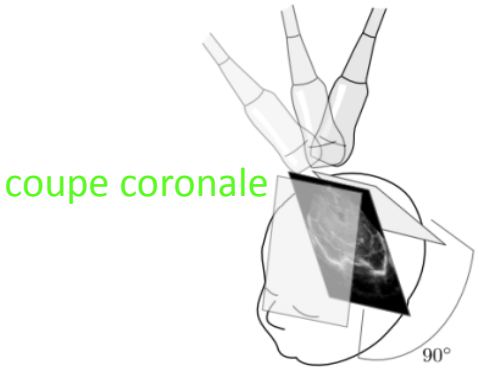
METHOD

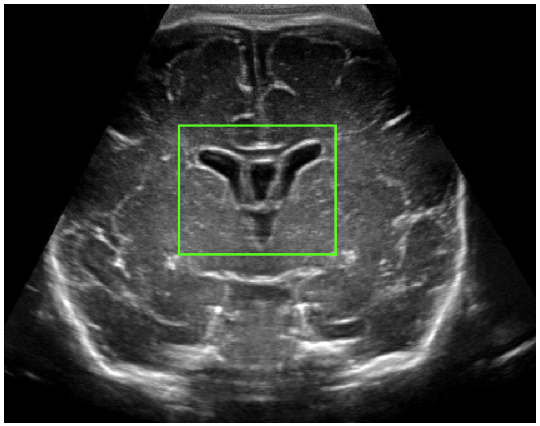
- Hyperbolic wavelet decomposition of both the input image and the PSF.
- The decomposition diagonalizes the convolution operation (like a Fourier decomposition, but for spatially varying kernels).
- This allows to perform all operations in the wavelet domain:

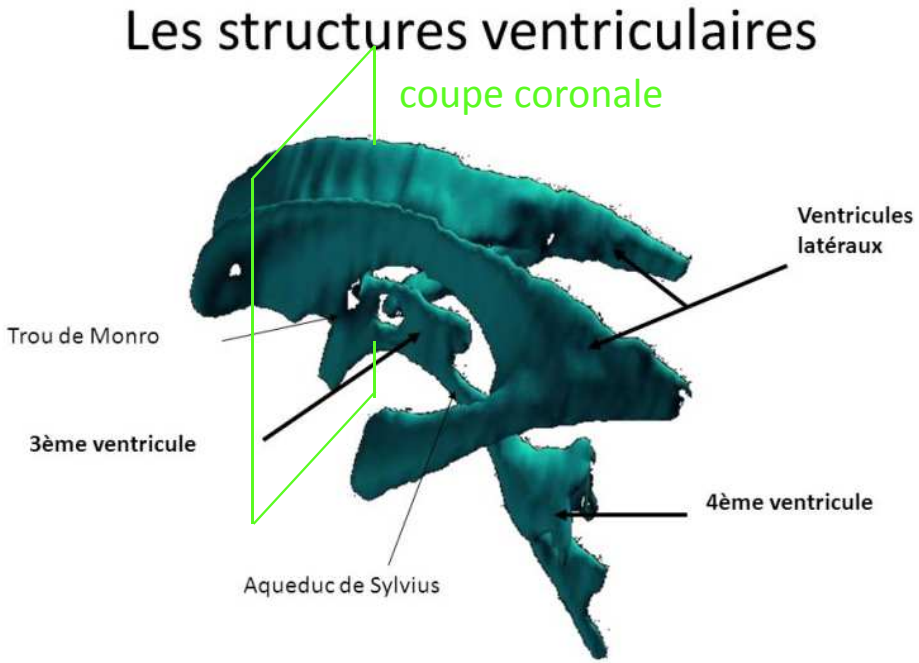
Stablization ⟶ Thresholding ⟶ PSF inversion

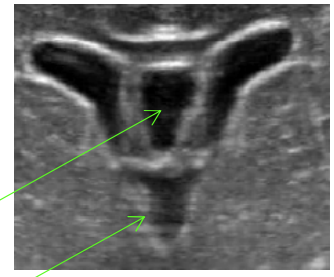
Application example

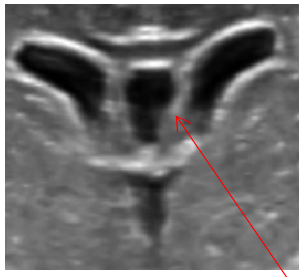
- 3D US imaging of the premature brain

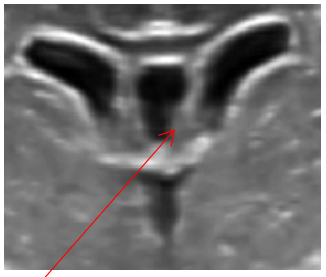


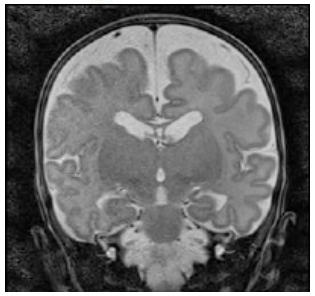





No denoising


Low level denoising


High level denoising


MRI

Cavum Pellucidum

3rd ventricule

Blurring of contours

Road map

- 1/ Understanding the wavelet-thresholding paradigm, the WF technique and the behavior of convolution operators in the wavelet-domain through the existing literature.
- 2/ Characterization of the PSF and its wavelet decomposition.
- 3/ Constructing a scheme for coupling despeckling and deconvolution.
- 4/ Validation of the algorithm on simulated and real data.
- 5/ Writing a scientific report on the results in English.