LOW-FREQUENCY IMAGE NOISE REMOVAL USING WHITE NOISE FILTER

Meisam Rakhshanfar and Maria A. Amer,
Department of Electrical and Computer Engineering

UNIVERSITÉ Concordia UNIVERSITY

Introduction

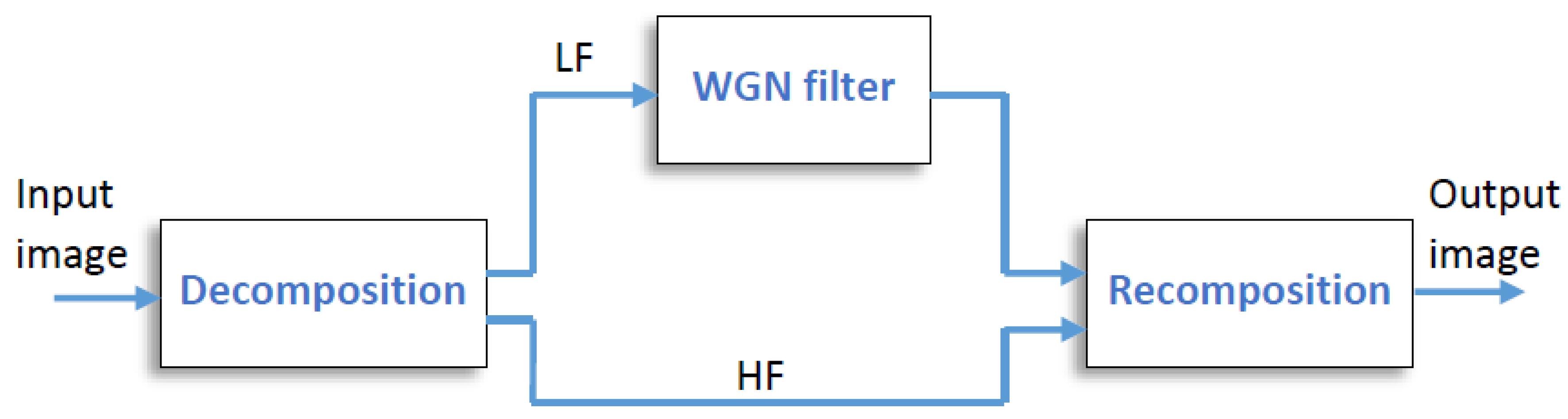
Problems:

- Real-world image/video capturing introduces **low-frequency** or **grainy** noise.
- High-frequency details of the image cannot be seen on a small display.
- Conventional noise reduction methods are designed to remove **white** or **all-frequency** noise.

Solution:

- We propose an approach for a coarse-grain removal using existing white noise filters.

Conventional Removal of Low Frequency Noise



Problem:

- HF contains noise ➔ output is still noisy

Our Algorithm:

1: Anti-aliasing (Low-pass) filter: $\boldsymbol{I}_h = \boldsymbol{I} * h_a$

2: Downscale and filter image using a white noise filter $\mathcal{A}^l = \boldsymbol{I}_h(0:2^l:\mathbf{c}\ ,\ 0:2^l:\mathbf{r})$

$$\mathcal{A}^l_F = \mathbf{WGF}(\mathcal{A}^l, \sigma_w)$$

3- Upscale filtered image and compute the residual image

$$z = \boldsymbol{I}_h - \mathbf{U}_l(\mathcal{A}^l_F)$$

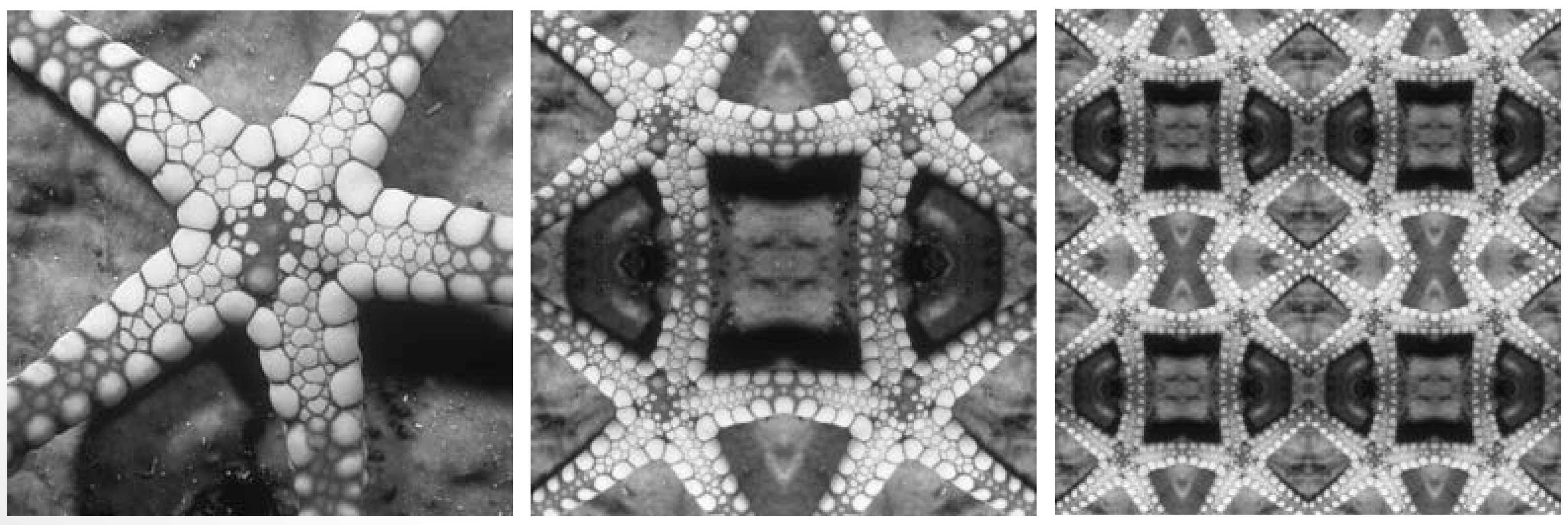
4- Filter the decoupled residual image using DCT shrinkage

$$\hat{z} = \mathbf{FDC}(\boldsymbol{I}_h) \qquad \tilde{z}_s = \hat{z}_s\left[1 - \mathbf{exp}(-p)\right], p = \mathbf{max}\left(\frac{|\hat{z}_s|}{c_t\sigma_w} - 1, 0\right)$$

5- inverse decouple

$$\boldsymbol{I}_F = \boldsymbol{I} - z + \bar{z}_s\ ,\ \bar{z}_s = \mathbf{IDC}(\tilde{z}_s)$$

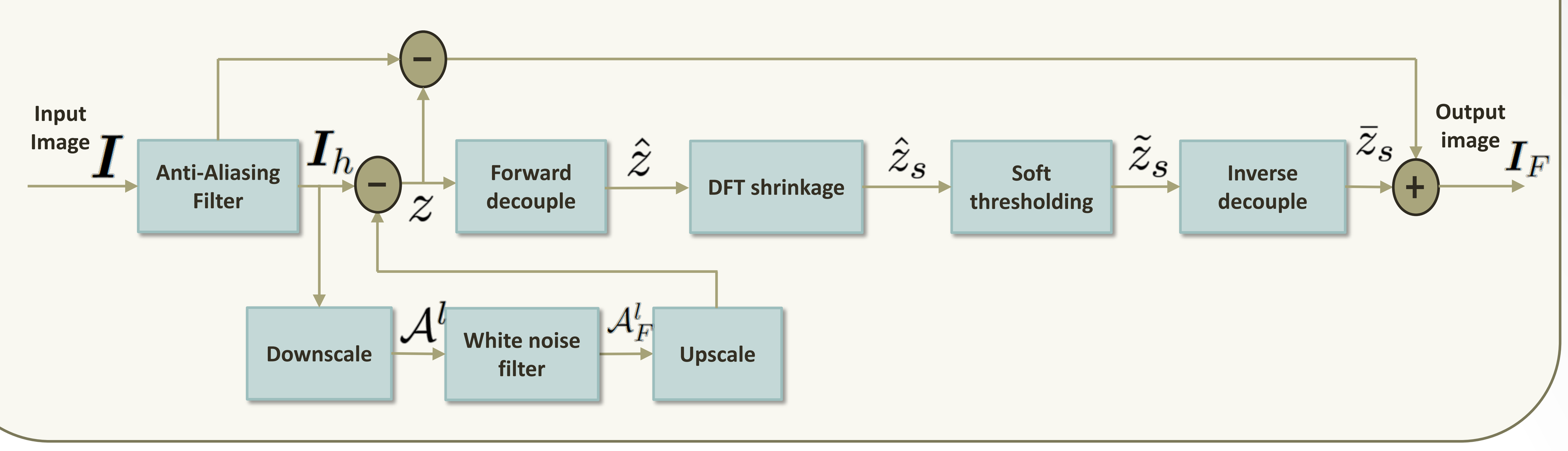
Decoupling makes the low-frequency noise less spatially correlated



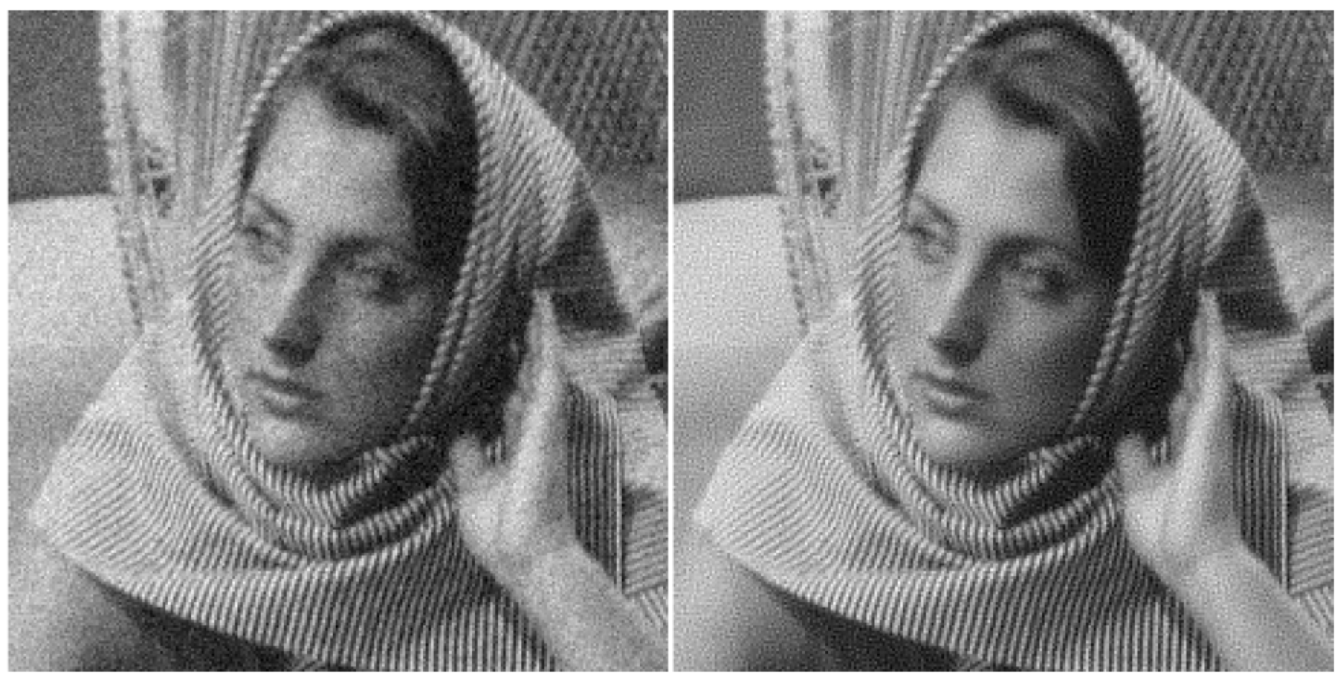
Original | Decoupled | Decoupled of decoupled

Decoupling of neighbor pixels

System Architecture



LF noise has a more impact on visual quality



White noise | Same PSNR | HF noise

Experimental results

Synthetic noise

$$I_n = I + n*h$$

n Gaussian noise with $\sigma_o = 15$

h Gaussian filter with $\sigma_{corr} = 0.6$

PSNR averaged over the TID2013 dataset degraded with LF noise, comparing proposed and related decomposition methods

WGN filter	Wavelet Harr	Wavelet D4	Gaussian pyramid bilinear	Gaussian pyramid bicubic	Gaussian pyramid Lanczos	Proposed
BM3D	31.94	32.02	31.41	31.87	32.02	32.97
PID	31.73	31.90	31.35	31.83	32.00	32.96

Real filtered and compressed noise

BM3D | BM3D in the proposed framework

Synthetic low-frequency noise

BM3D | BM3D in the proposed framework