

Supplementary material for the paper:

“Image denoising: Can plain Neural Networks compete with BM3D?”

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- Input weights page 2

The weights in the input layer act as useful feature extractors from noisy data but are difficult to interpret.

- Output weights page 3

The weights in the output layer resemble a dictionary. The MLP constructs outputs using a linear combination of the elements of this dictionary. The previous layers of the MLP are a non-linear function which finds the proper linear coefficients for the output layer.

- Images where we outperform BM3D page 4

19 images of the VOC dataset and 5 images from the McGill dataset where our MLP outperforms BM3D. Many of these images are natural scenes.

VOC images page 4

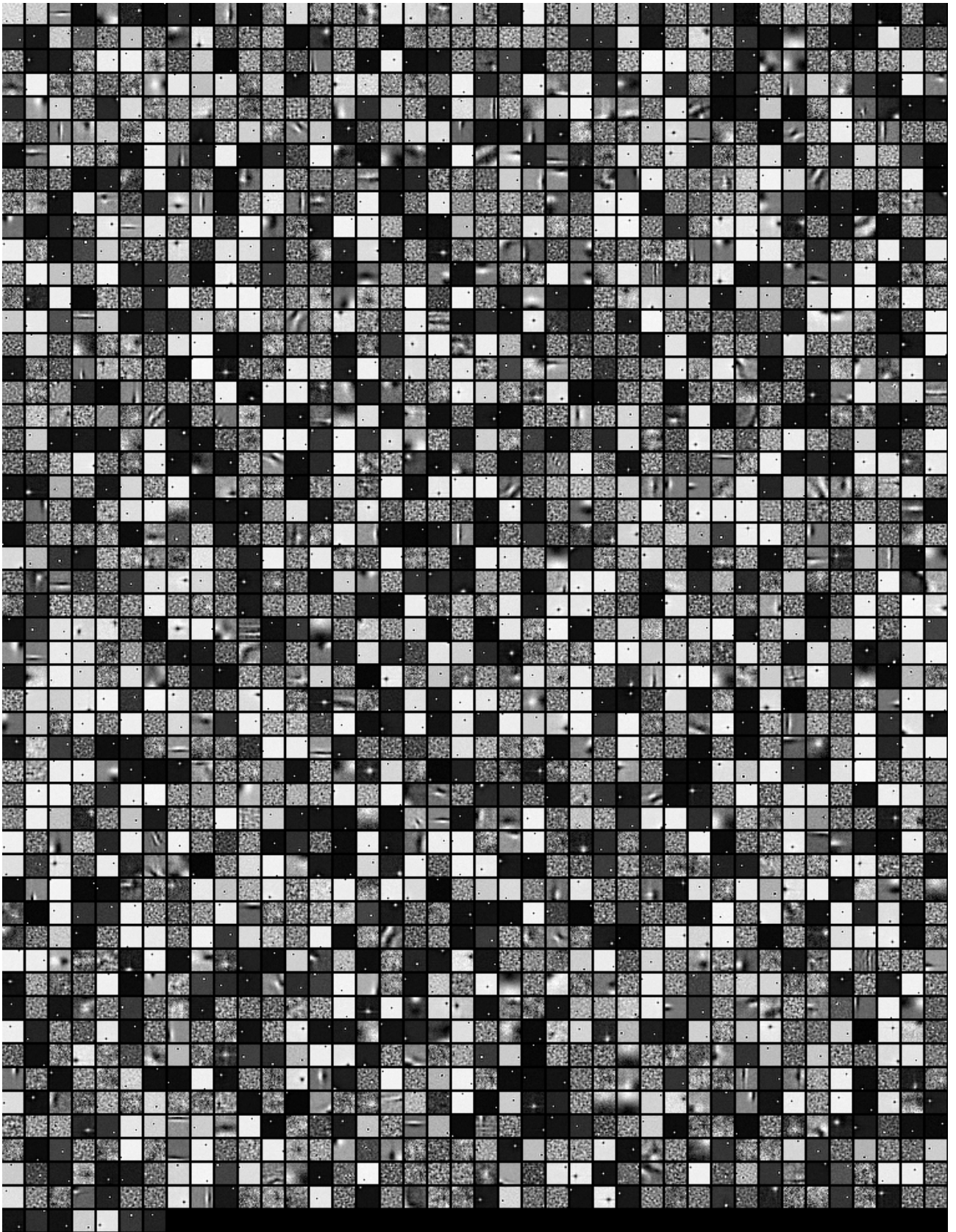
McGill images page 23

- Images where BM3D outperforms us page 28

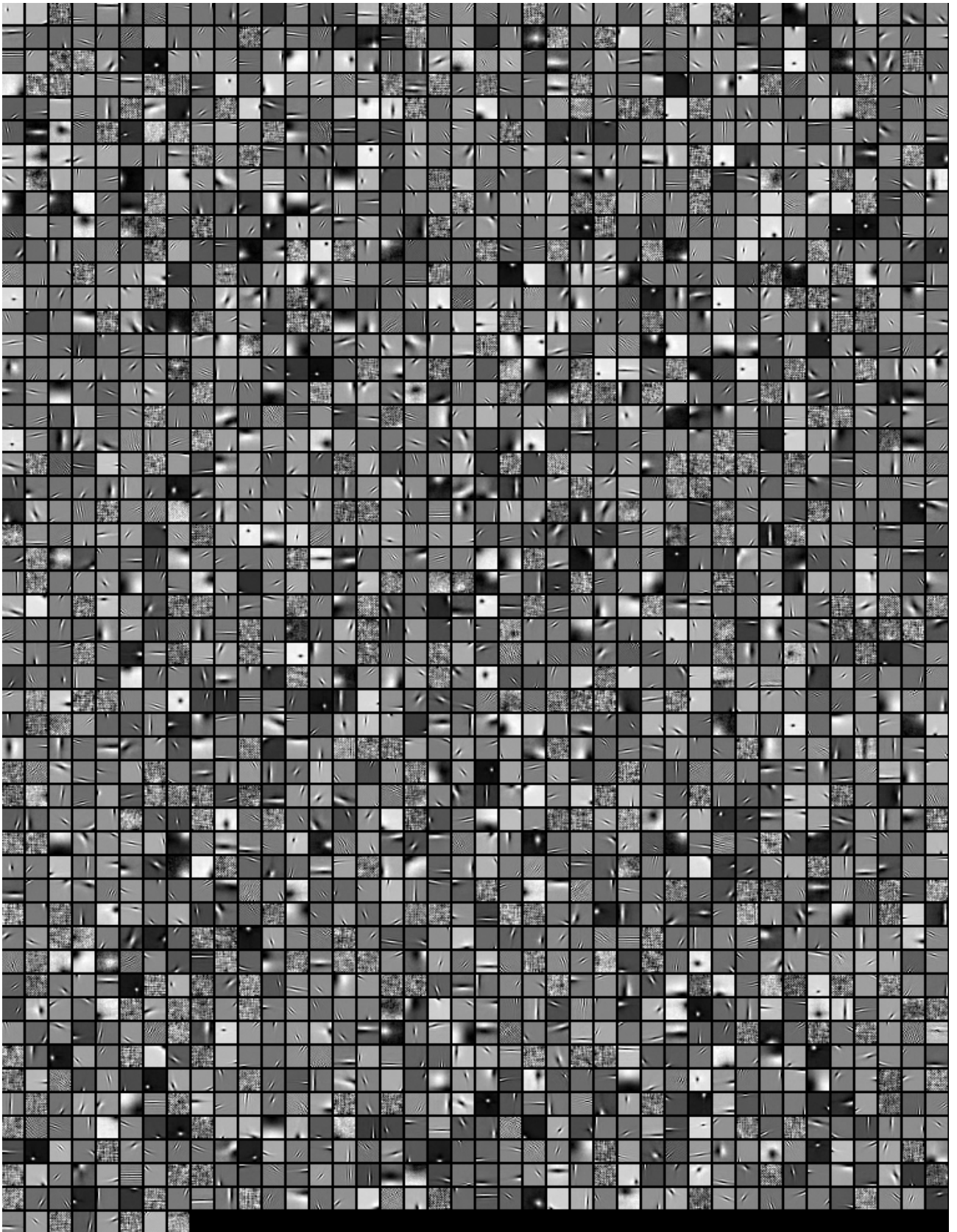
19 images of the VOC dataset and 5 images from the McGill dataset where BM3D outperforms our MLP. Many of these images contain man-made structures or textures with regularly repeating patterns.

VOC images page 28

McGill images page 47



This image is a representation of all weights connecting the input layer to the first hidden layer. Each patch is a representation of the weights connecting all input pixels to one hidden neuron. Each patch has been normalized to use the full range of pixel values $([0..255])$.

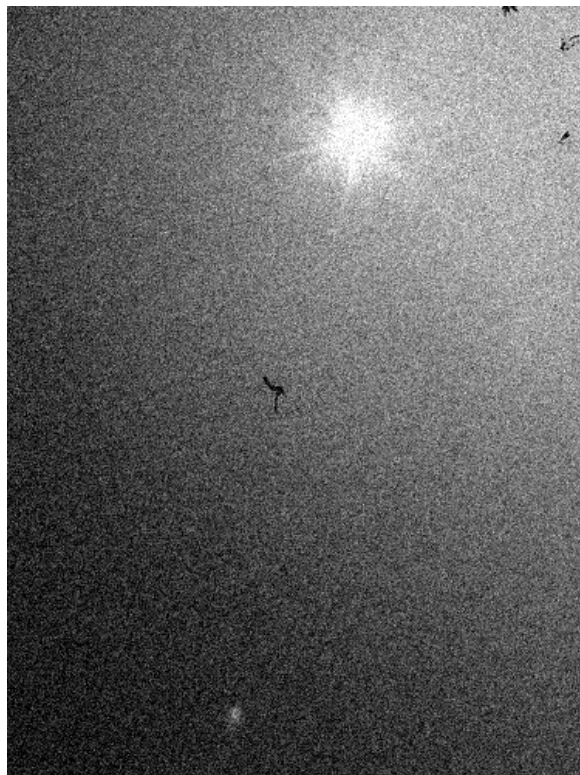


This image is a representation of all weights connecting the last hidden layer to the output. Each patch is a representation of the weights connecting one hidden neuron to all output pixels. Each patch has been normalized to use the full range of pixel values $([0..255])$.

Dataset: VOC, Image name: 004513, size: 375×500, rotated by 90 degrees.



noise-free



noisy, PSNR: 20.16dB



BM3D: PSNR: 38.97 dB



our result: **39.63dB**

Dataset: VOC, Image name: 003402, size: 375×500 , rotated by 90 degrees.



noise-free



noisy, PSNR: 20.16dB



BM3D: PSNR: 23.17 dB

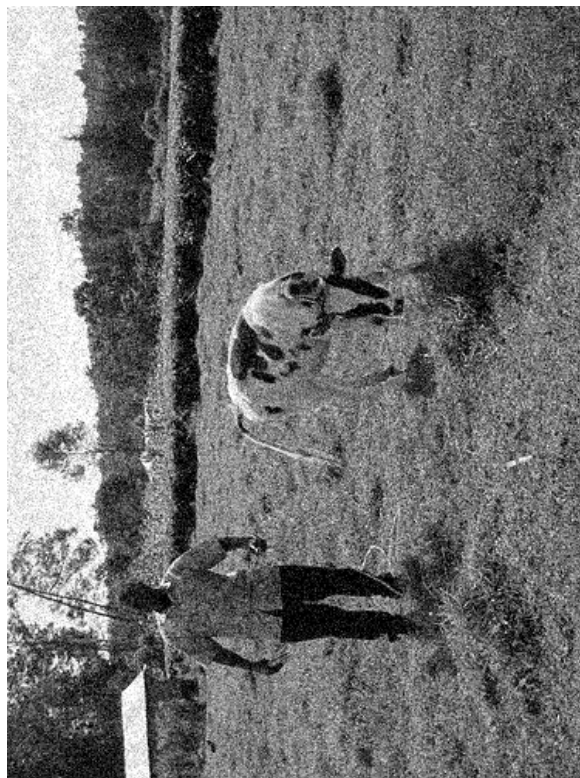


our result: **23.74dB**

Dataset: VOC, Image name: 005617, size: 375×500, rotated by 90 degrees.



noise-free



noisy, PSNR: 20.20dB

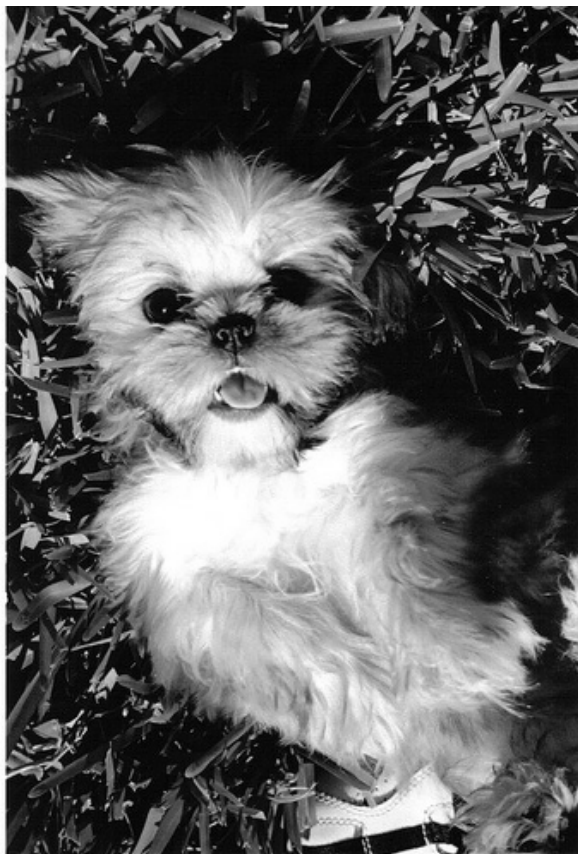


BM3D: PSNR: 24.19 dB

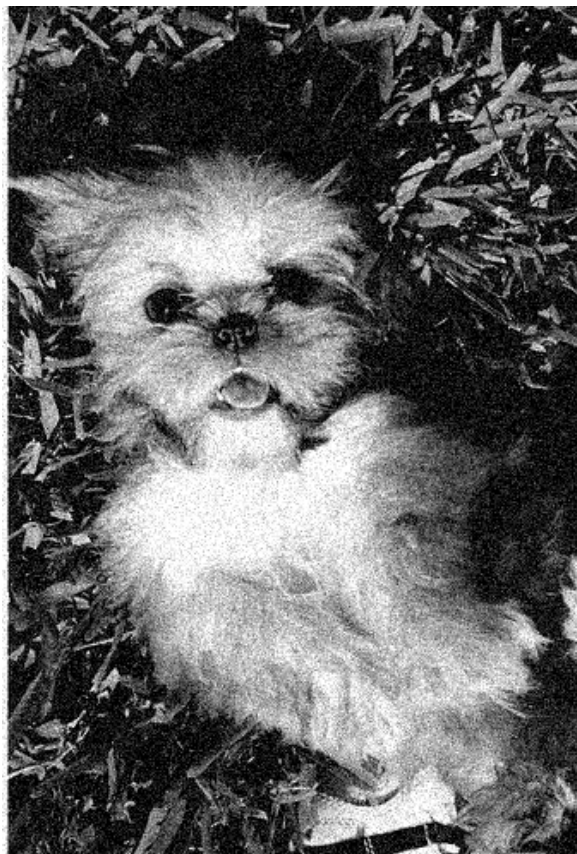


our result: **24.72dB**

Dataset: VOC, Image name: 003901, size: 500×338



noise-free



noisy, PSNR: 20.17dB



BM3D: PSNR: 26.37 dB

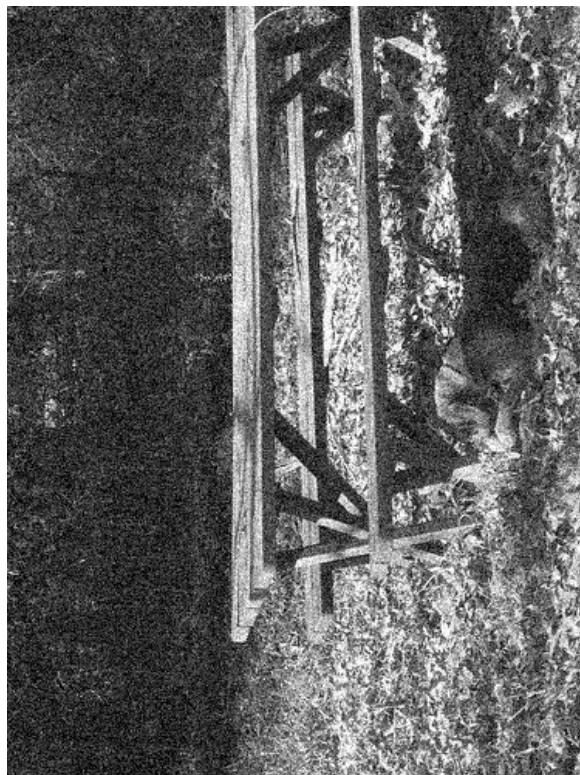


our result: **26.89dB**

Dataset: VOC, Image name: 007930, size: 375×500, rotated by 90 degrees.



noise-free



noisy, PSNR: 20.20dB



BM3D: PSNR: 24.40 dB

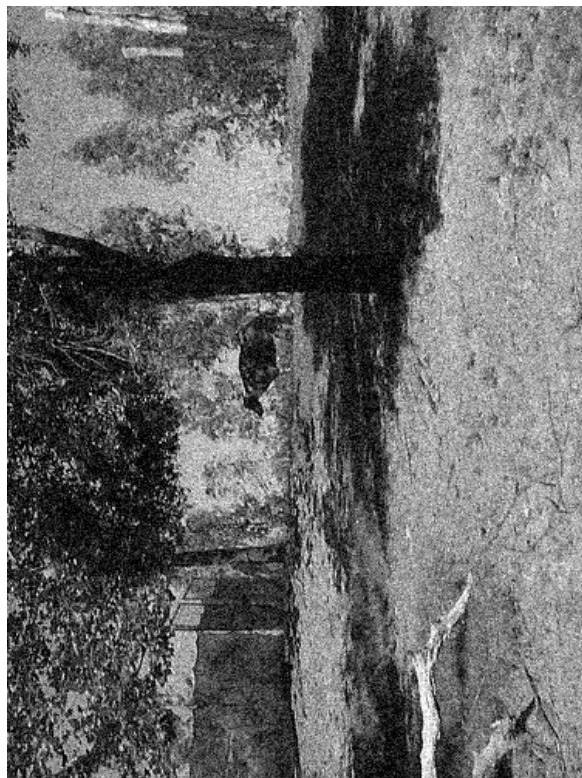


our result: **24.90dB**

Dataset: VOC, Image name: 000273, size: 375×500 , rotated by 90 degrees.



noise-free



noisy, PSNR: 20.17dB



BM3D: PSNR: 25.09 dB



our result: **25.58dB**

Dataset: VOC, Image name: 008255, size: 500×384



noise-free



noisy, PSNR: 20.18dB



BM3D: PSNR: 27.17 dB

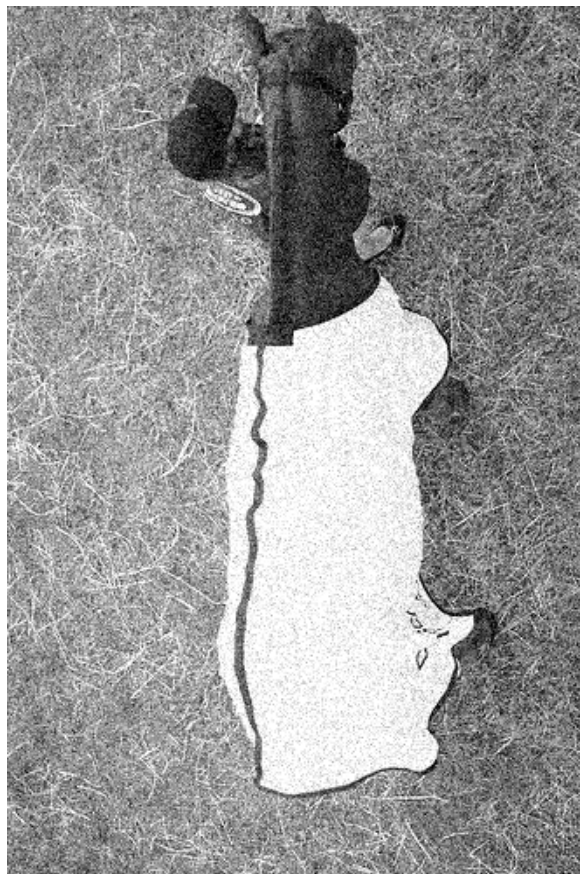


our result: **27.65dB**

Dataset: VOC, Image name: 009937, size: 332×500, rotated by 90 degrees.



noise-free



noisy, PSNR: 20.16dB



BM3D: PSNR: 23.34 dB



our result: **23.82dB**

Dataset: VOC, Image name: 009925, size: 354×500, rotated by 90 degrees.



noise-free



noisy, PSNR: 20.14dB



BM3D: PSNR: 29.65 dB



our result: **30.12dB**

Dataset: VOC, Image name: 006776, size: 375×500 , rotated by 90 degrees.



noise-free



noisy, PSNR: 20.19dB



BM3D: PSNR: 24.39 dB

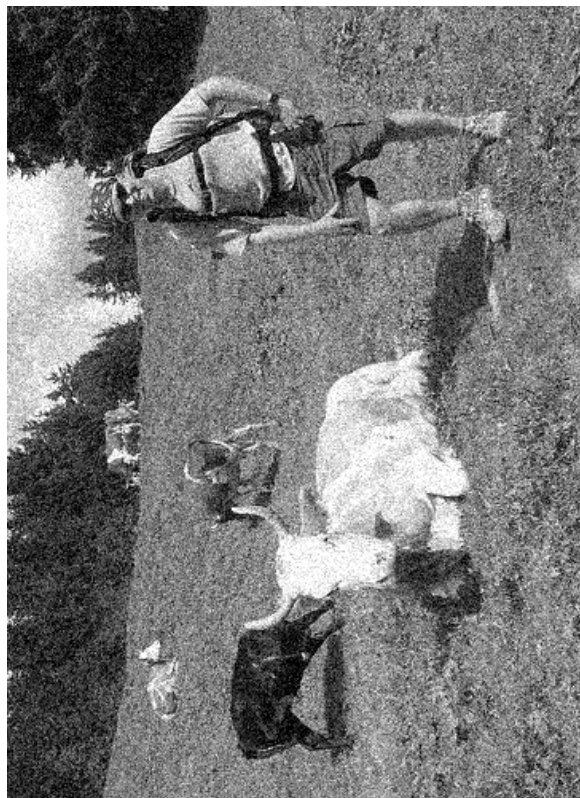


our result: **24.86dB**

Dataset: VOC, Image name: 008758, size: 364×500, rotated by 90 degrees.



noise-free



noisy, PSNR: 20.19dB



BM3D: PSNR: 24.14 dB



our result: **24.60dB**

Dataset: VOC, Image name: 006969, size: 375×500 , rotated by 90 degrees.



noise-free



noisy, PSNR: 20.18dB



BM3D: PSNR: 23.18 dB



our result: **23.63dB**

Dataset: VOC, Image name: 003943, size: 375×500, rotated by 90 degrees.



noise-free



noisy, PSNR: 20.20dB

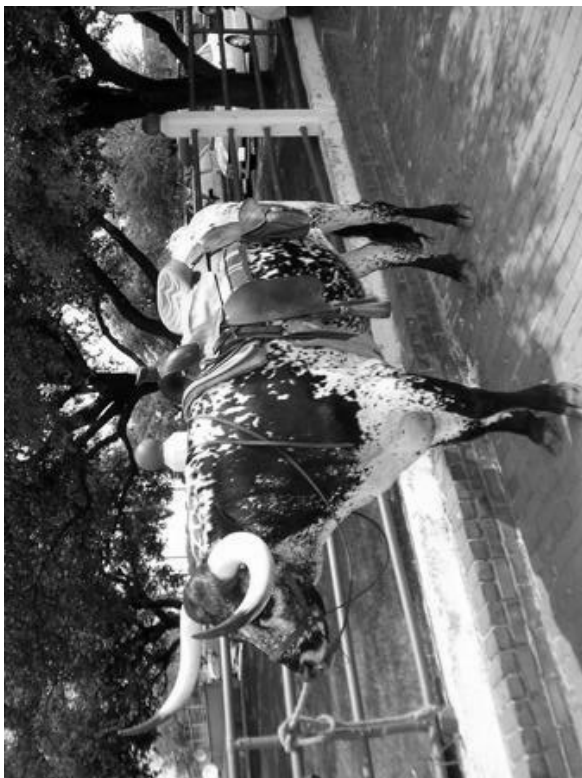


BM3D: PSNR: 30.27 dB

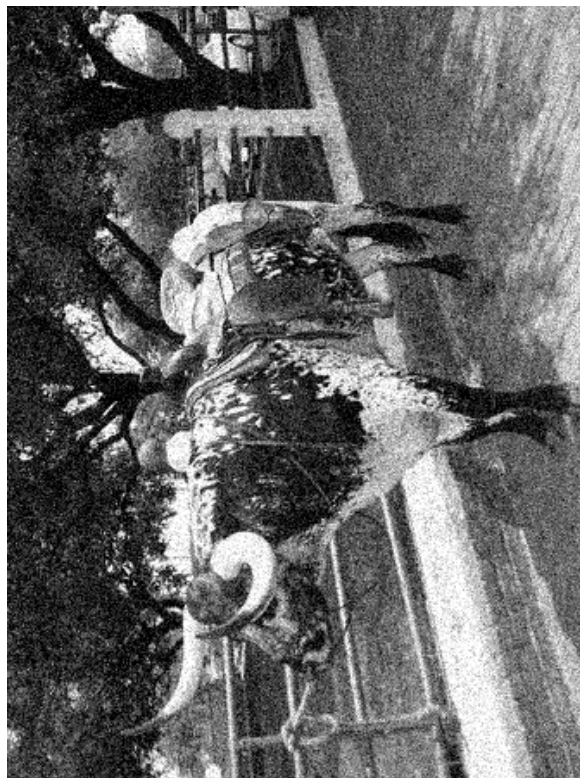


our result: **30.71dB**

Dataset: VOC, Image name: 007118, size: 336×448, rotated by 90 degrees.



noise-free



noisy, PSNR: 20.16dB



BM3D: PSNR: 26.25 dB



our result: **26.70dB**

Dataset: VOC, Image name: 003096, size: 224×300, rotated by 90 degrees.



noise-free



noisy, PSNR: 20.17dB



BM3D: PSNR: 25.22 dB

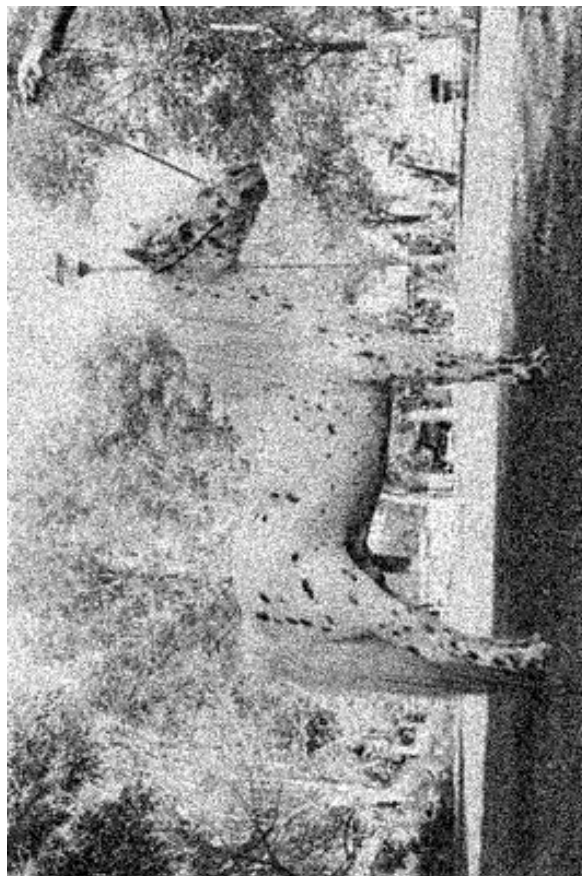


our result: **25.65dB**

Dataset: VOC, Image name: 003832, size: 265×400 , rotated by 90 degrees.



noise-free



noisy, PSNR: 20.14dB



BM3D: PSNR: 25.38 dB

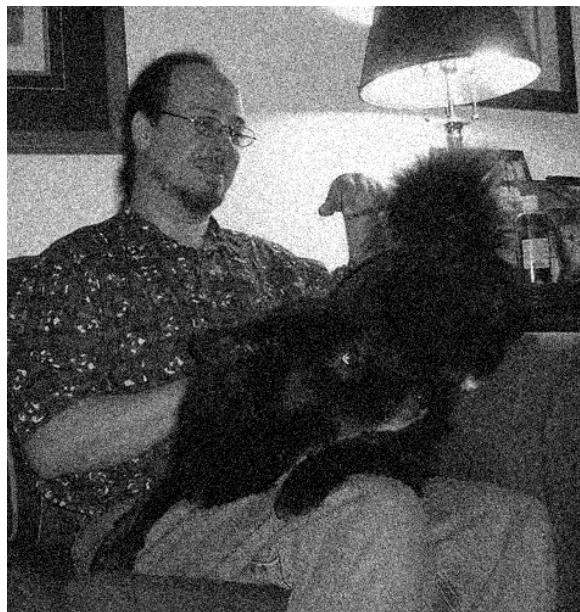


our result: **25.81dB**

Dataset: VOC, Image name: 002207, size: 500×476



noise-free



noisy, PSNR: 20.15dB



BM3D: PSNR: 30.54 dB



our result: **30.97dB**

Dataset: VOC, Image name: 009716, size: 374×500, rotated by 90 degrees.



noise-free



noisy, PSNR: 20.18dB



BM3D: PSNR: 29.51 dB



our result: **29.94dB**

Dataset: VOC, Image name: 002573, size: 375×500, rotated by 90 degrees.



noise-free



noisy, PSNR: 20.17dB

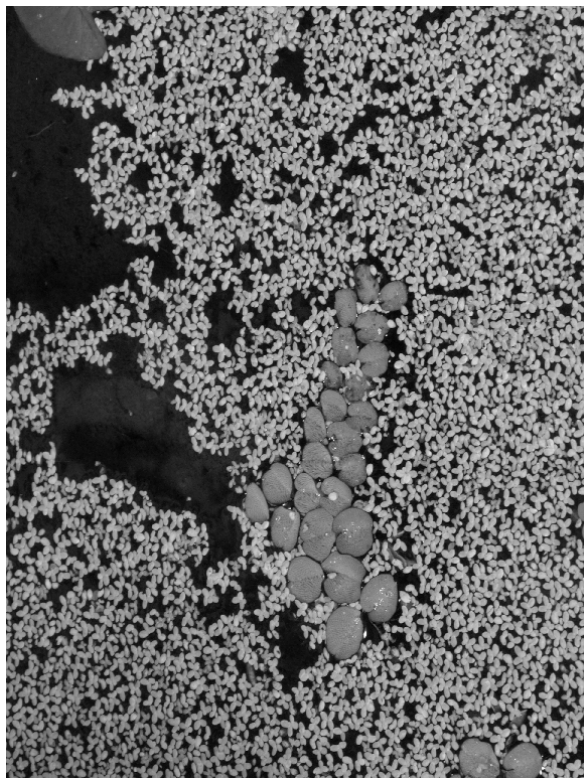


BM3D: PSNR: 25.13 dB

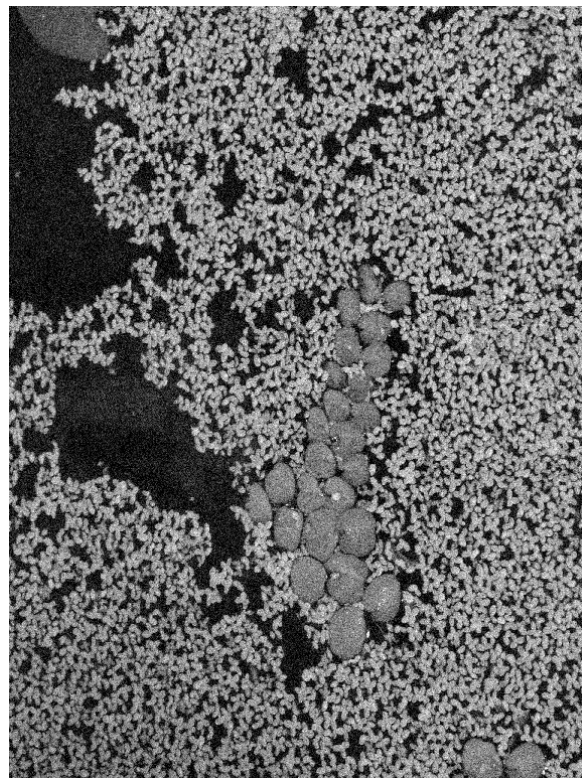


our result: **25.55dB**

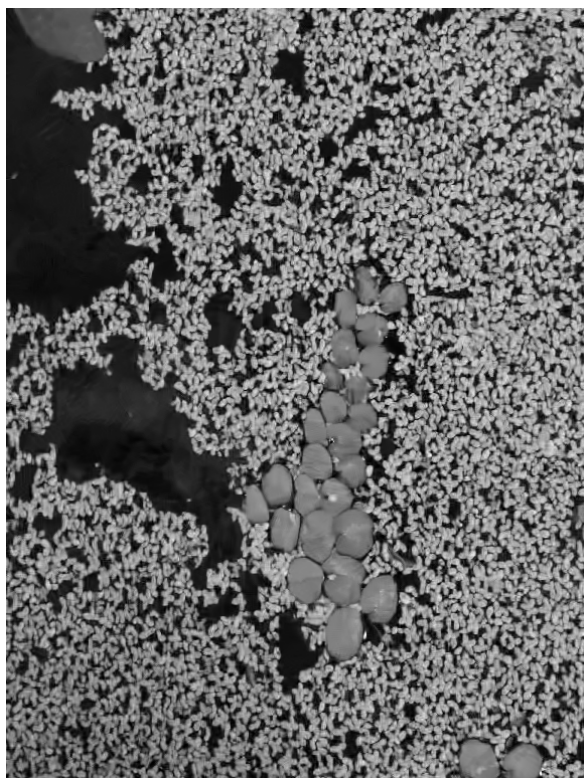
Dataset: McGill, Image name: pippin0120, size: 576×768 , rotated by 90 degrees.



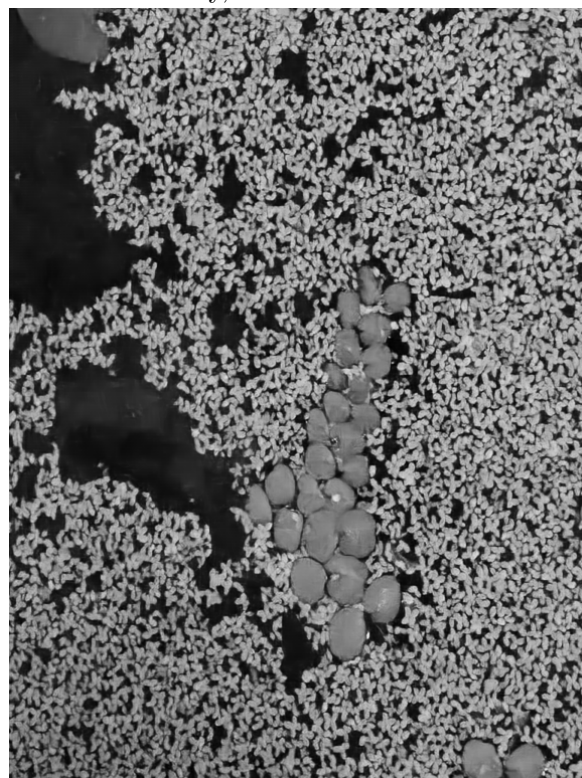
noise-free



noisy, PSNR: 25.54dB



BM3D: PSNR: 24.91 dB



our result: **25.71dB**

Dataset: McGill, Image name: pippin0010, size: 768×512



noise-free



noisy, PSNR: 26.62dB



BM3D: PSNR: 26.29 dB



our result: **26.80dB**

Dataset: McGill, Image name: Merry-0039-Lasalle, size: 576×768 , rotated by 90 degrees.



noise-free



noisy, PSNR: 26.42dB



BM3D: PSNR: 26.04 dB

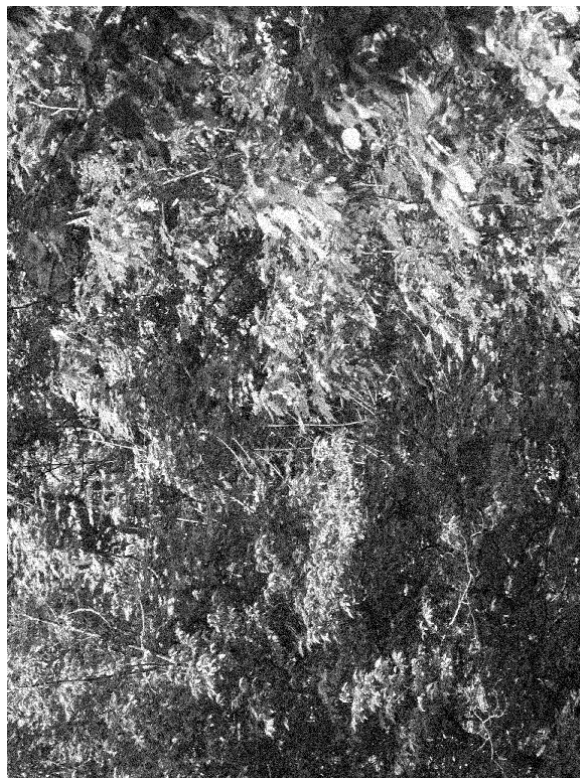


our result: **26.54dB**

Dataset: McGill, Image name: pippin-Peel076, size: 576×768 , rotated by 90 degrees.



noise-free



noisy, PSNR: 24.29dB



BM3D: PSNR: 23.95 dB



our result: **24.42dB**

Dataset: McGill, Image name: pippin-jamaica0246, size: 576×768 , rotated by 90 degrees.



noise-free



noisy, PSNR: 26.84dB

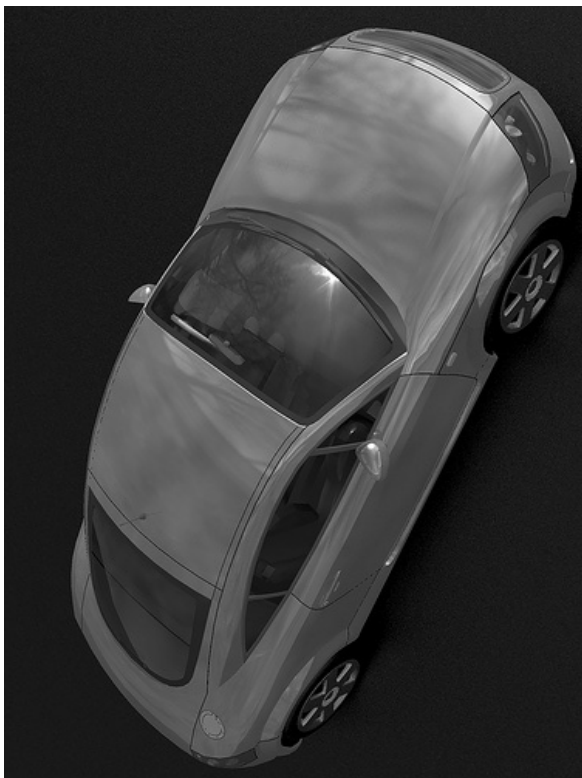


BM3D: PSNR: 26.58 dB

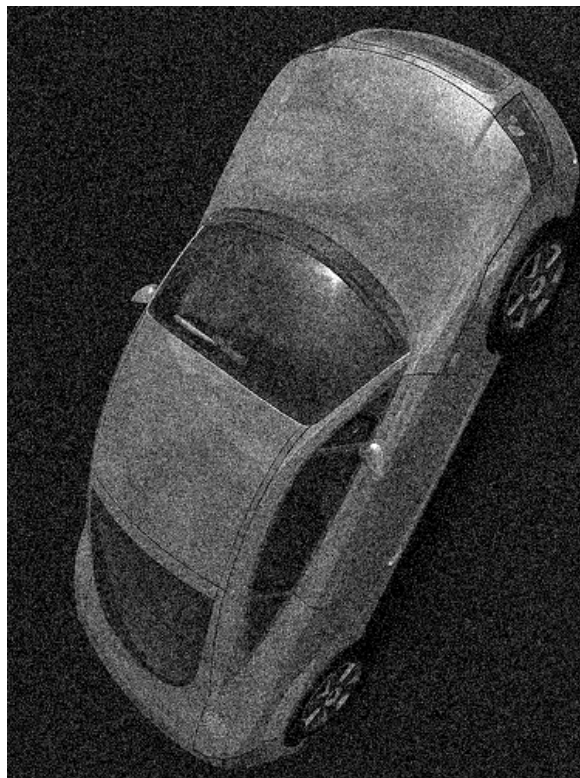


our result: **27.05dB**

Dataset: VOC, Image name: 007459, size: 375×500, rotated by 90 degrees.



noise-free



noisy, PSNR: 20.16dB



BM3D: PSNR: **32.98** dB



our result: 31.80dB

Dataset: VOC, Image name: 007043, size: 333×500, rotated by 90 degrees.



noise-free



noisy, PSNR: 20.18dB



BM3D: PSNR: 29.51 dB



our result: 28.64dB

Dataset: VOC, Image name: 008600, size: 335×500, rotated by 90 degrees.



noise-free



noisy, PSNR: 20.17dB



BM3D: PSNR: **29.67** dB



our result: 28.85dB

Dataset: VOC, Image name: 003607, size: 500×375



noise-free



noisy, PSNR: 20.17dB



BM3D: PSNR: **31.01** dB



our result: 30.19dB

Dataset: VOC, Image name: 008972, size: 500×481



noise-free



noisy, PSNR: 20.18dB



BM3D: PSNR: **29.90** dB



our result: 29.11dB

Dataset: VOC, Image name: 009262, size: 333×500, rotated by 90 degrees.



noise-free



noisy, PSNR: 20.18dB



BM3D: PSNR: **32.73** dB



our result: 31.98dB

Dataset: VOC, Image name: 002073, size: 333×500, rotated by 90 degrees.



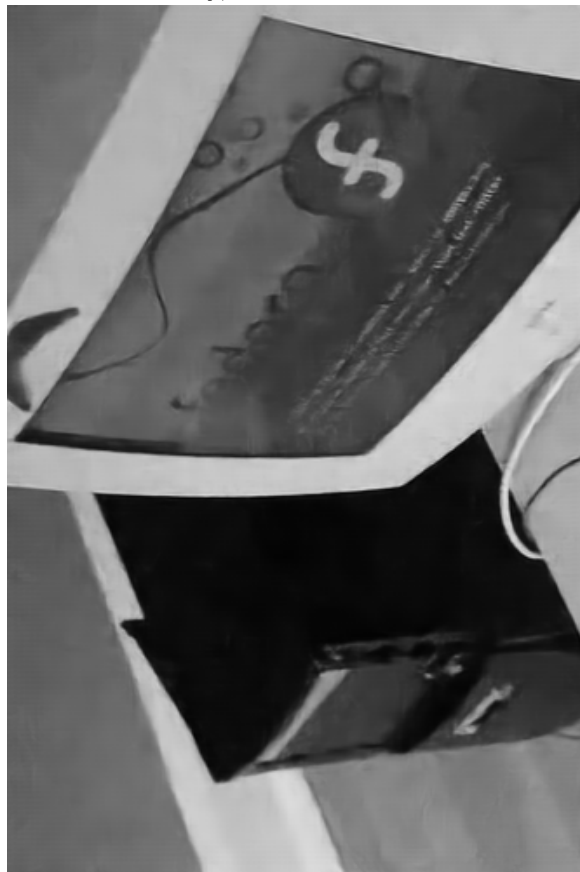
noise-free



noisy, PSNR: 20.17dB



BM3D: PSNR: **34.85** dB



our result: 34.10dB

Dataset: VOC, Image name: 003400, size: 375×500, rotated by 90 degrees.



noise-free



noisy, PSNR: 20.18dB



BM3D: PSNR: 30.22 dB



our result: 29.49dB

Dataset: VOC, Image name: 000957, size: 375×500, rotated by 90 degrees.



noise-free



noisy, PSNR: 20.20dB



BM3D: PSNR: 25.57 dB

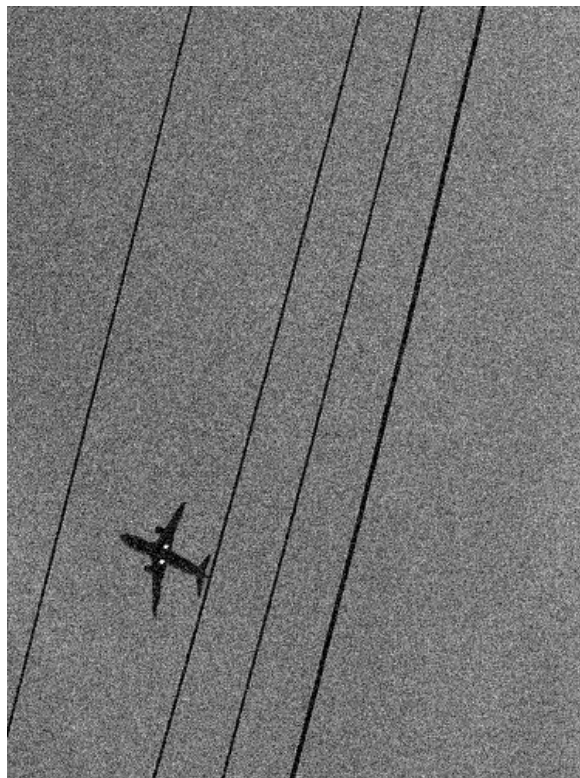


our result: 24.84dB

Dataset: VOC, Image name: 004752, size: 375×500 , rotated by 90 degrees.



noise-free



noisy, PSNR: 20.18dB



BM3D: PSNR: **32.81** dB



our result: 32.10dB

Dataset: VOC, Image name: 005321, size: 333×500, rotated by 90 degrees.



noise-free



noisy, PSNR: 20.16dB



BM3D: PSNR: **31.56** dB

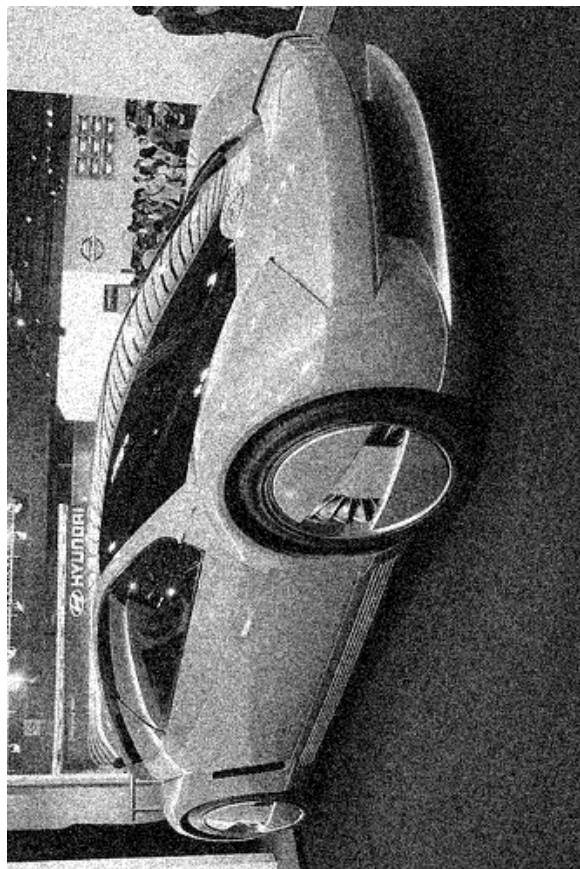


our result: 30.89dB

Dataset: VOC, Image name: 001511, size: 333×500, rotated by 90 degrees.



noise-free



noisy, PSNR: 20.17dB



BM3D: PSNR: 29.00 dB

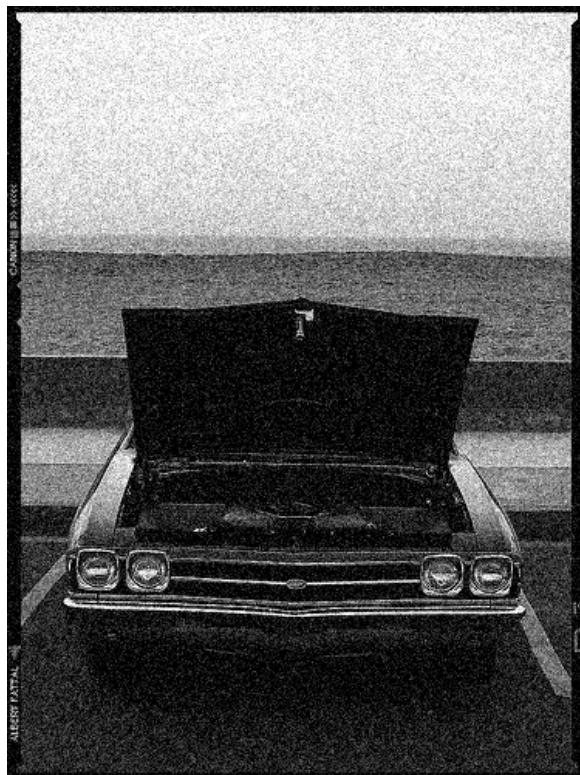


our result: 28.38dB

Dataset: VOC, Image name: 000300, size: 500×375



noise-free



noisy, PSNR: 20.17dB

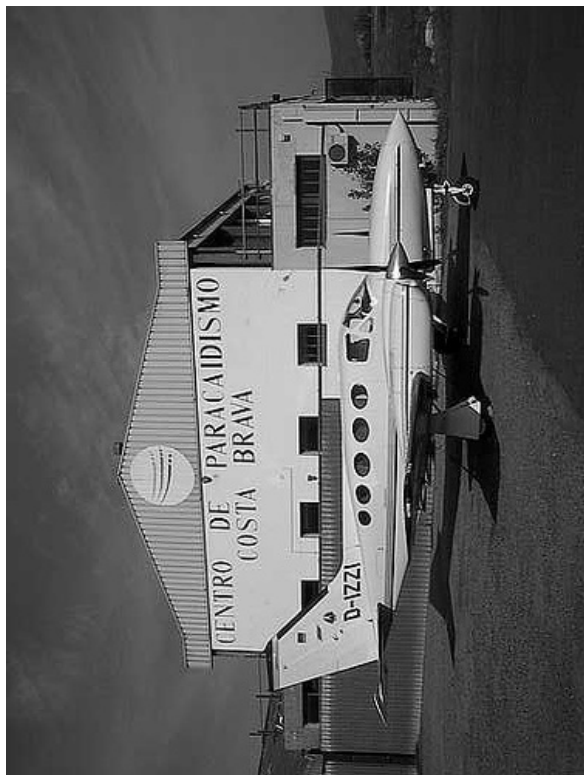


BM3D: PSNR: 30.37 dB

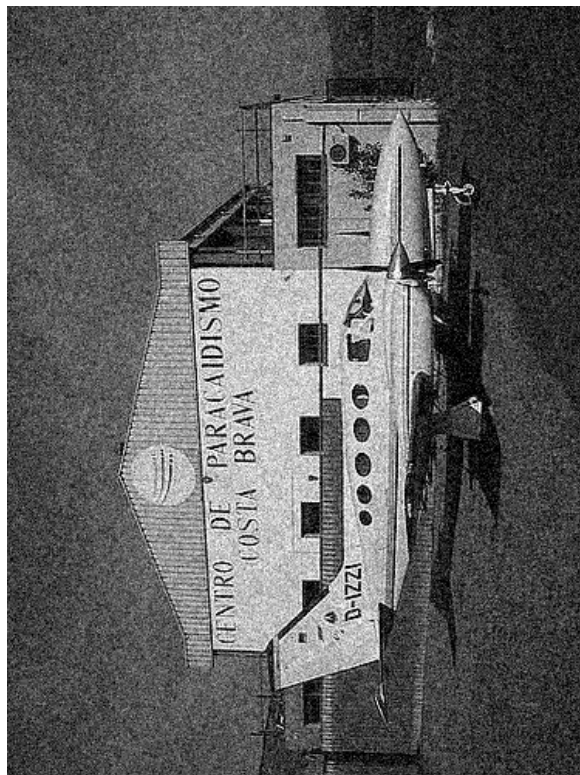


our result: 29.76dB

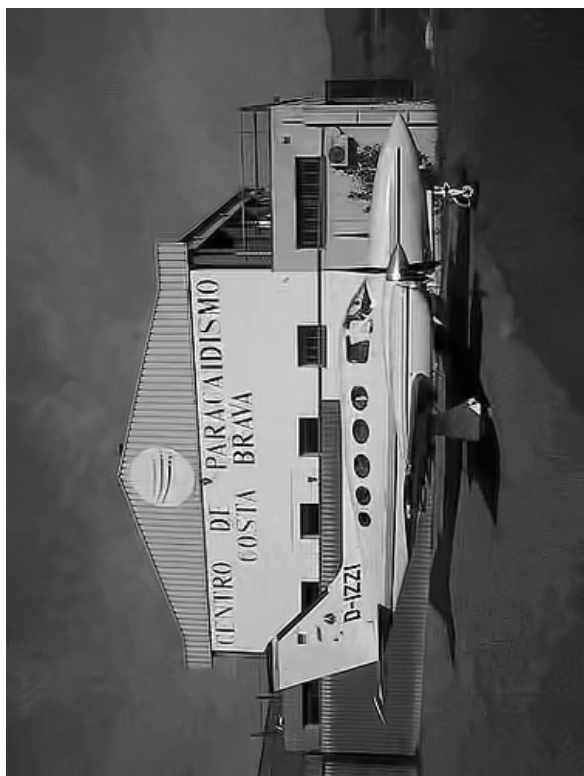
Dataset: VOC, Image name: 002357, size: 375×500, rotated by 90 degrees.



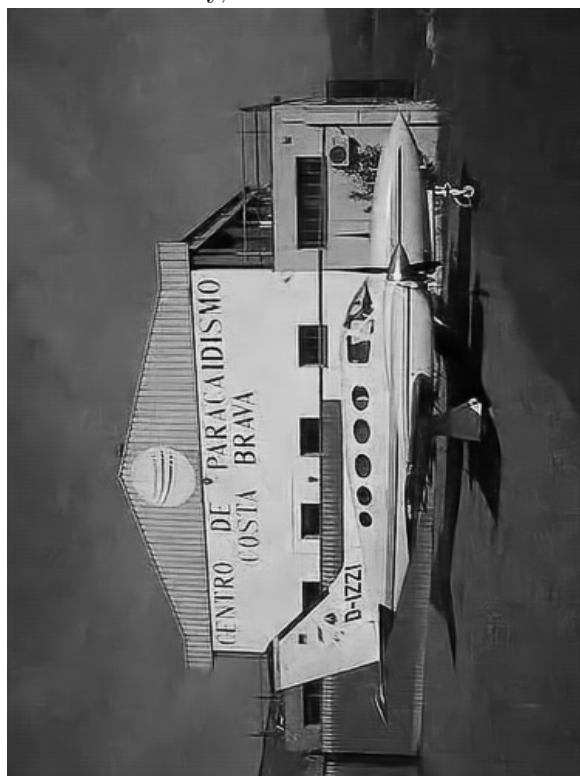
noise-free



noisy, PSNR: 20.19dB



BM3D: PSNR: 28.51 dB



our result: 27.91dB

Dataset: VOC, Image name: 005681, size: 382×472, rotated by 90 degrees.



noise-free



noisy, PSNR: 20.17dB



BM3D: PSNR: **38.08** dB



our result: 37.50dB

Dataset: VOC, Image name: 002066, size: 500×375



noise-free



noisy, PSNR: 20.15dB



BM3D: PSNR: 29.07 dB

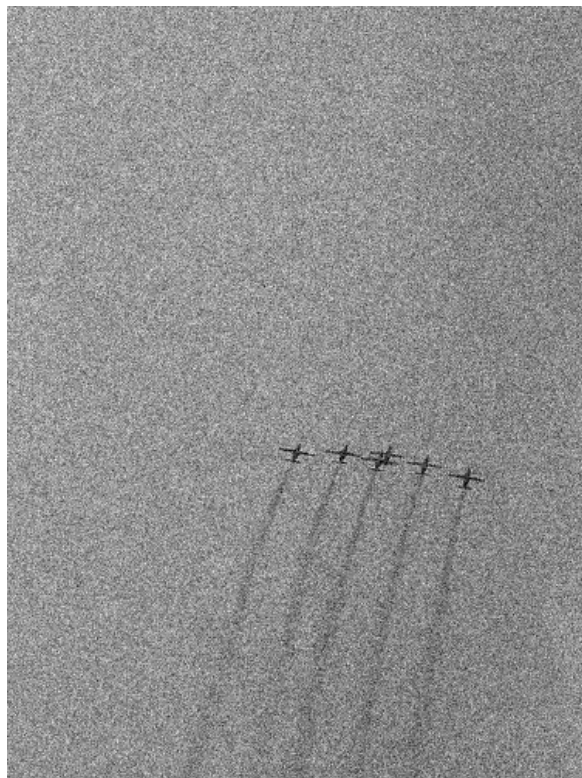


our result: 28.50dB

Dataset: VOC, Image name: 004377, size: 375×500, rotated by 90 degrees.



noise-free



noisy, PSNR: 20.19dB



BM3D: PSNR: **39.65** dB

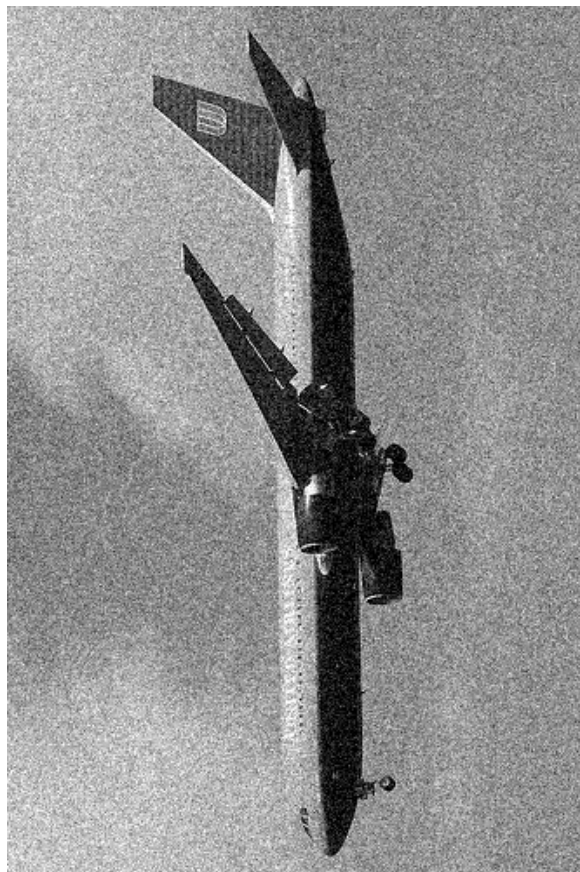


our result: 39.08dB

Dataset: VOC, Image name: 006263, size: 333×500, rotated by 90 degrees.



noise-free



noisy, PSNR: 20.17dB



BM3D: PSNR: **34.38** dB

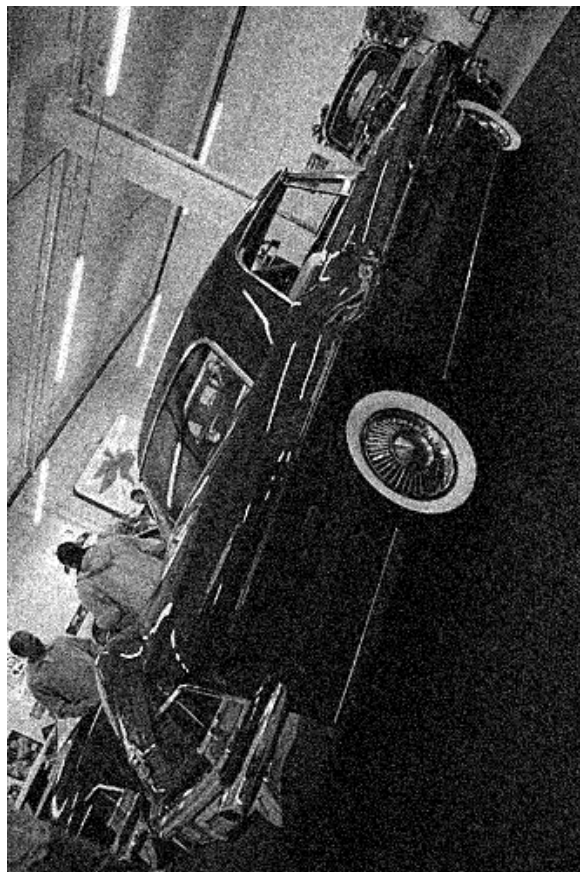


our result: 33.87dB

Dataset: VOC, Image name: 006016, size: 333×500, rotated by 90 degrees.



noise-free



noisy, PSNR: 20.18dB



BM3D: PSNR: 28.45 dB

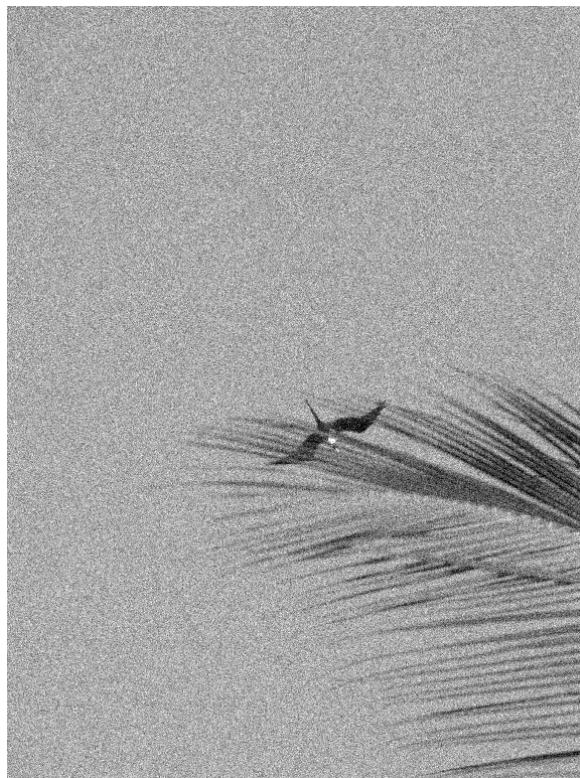


our result: 27.97dB

Dataset: McGill, Image name: merry-mexico0152, size: 576×768 , rotated by 90 degrees.



noise-free



noisy, PSNR: 35.36dB

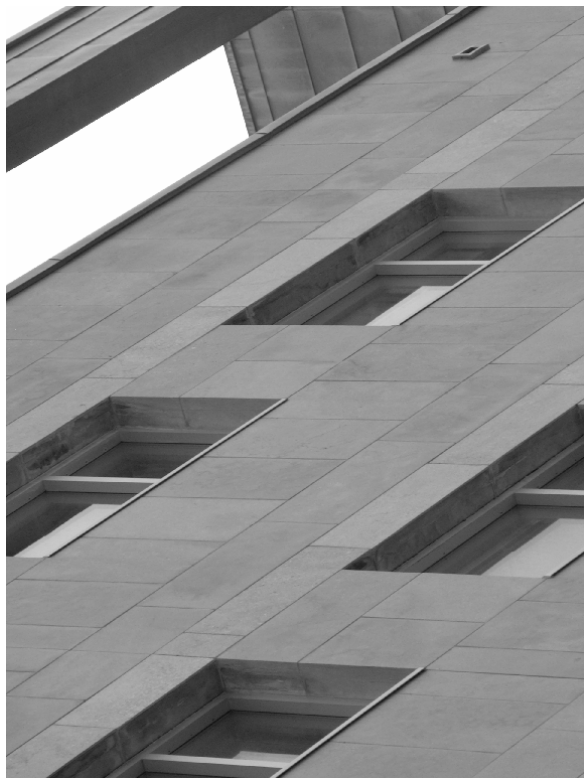


BM3D: PSNR: **37.06** dB



our result: 35.74dB

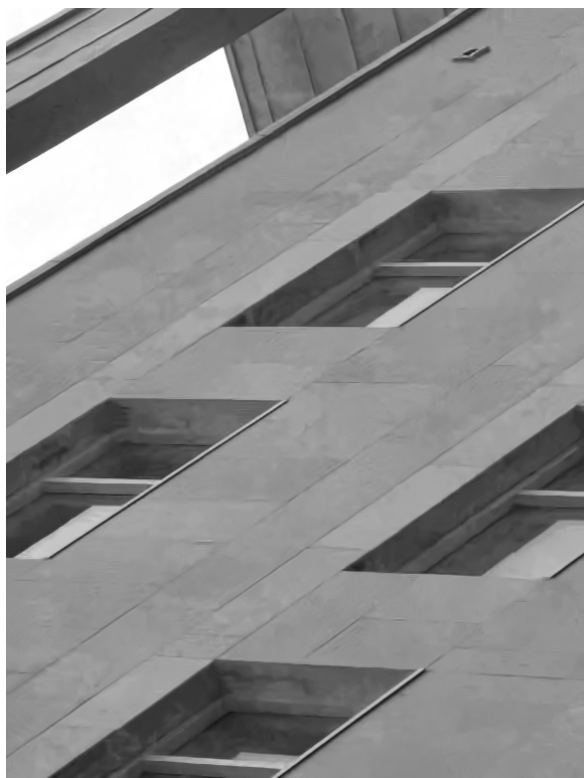
Dataset: McGill, Image name: pippin-UniStrt027, size: 576×768, rotated by 90 degrees.



noise-free



noisy, PSNR: 33.15dB

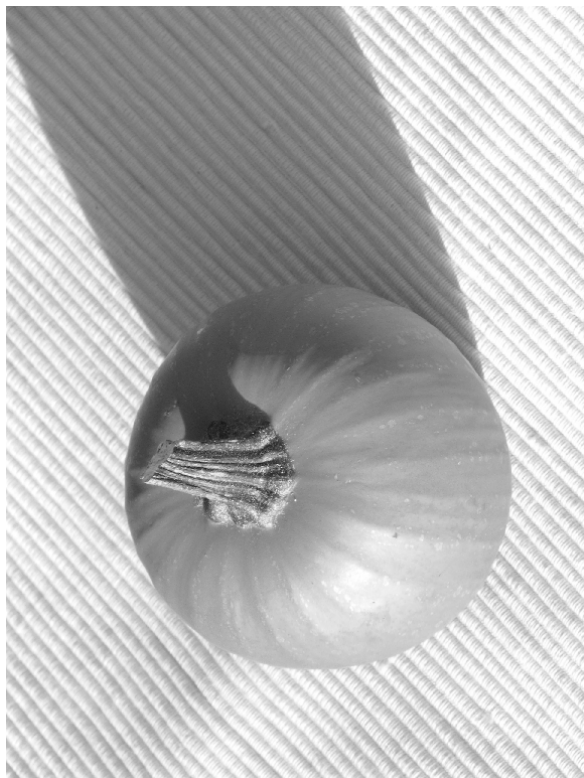


BM3D: PSNR: **34.33** dB

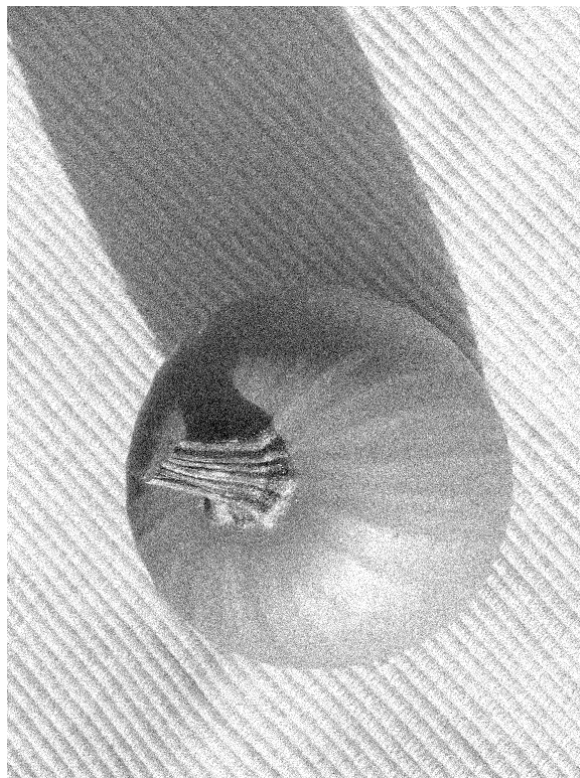


our result: 33.44dB

Dataset: McGill, Image name: merry0102, size: 576×768, rotated by 90 degrees.



noise-free



noisy, PSNR: 30.64dB



BM3D: PSNR: **31.61** dB



our result: 30.87dB

Dataset: McGill, Image name: merry-mexico0065, size: 576×768 , rotated by 90 degrees.



noise-free



noisy, PSNR: 31.75dB

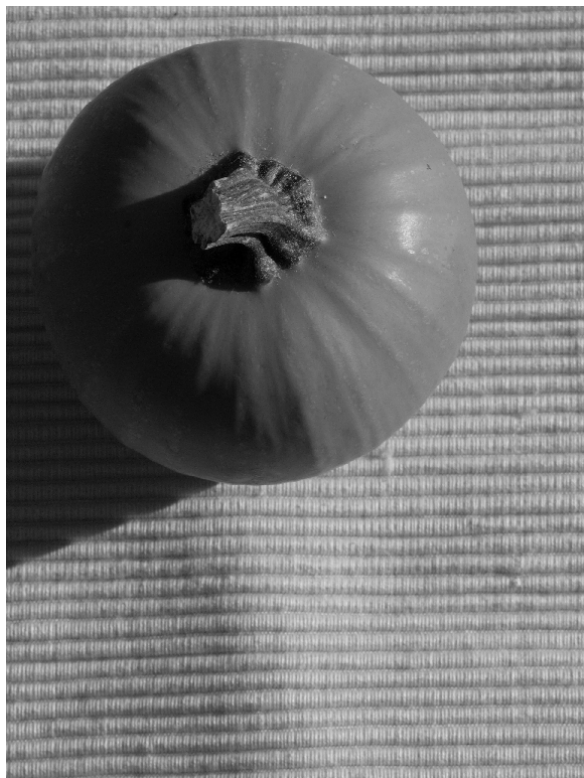


BM3D: PSNR: **32.63** dB



our result: 31.98dB

Dataset: McGill, Image name: merry0099, size: 576×768, rotated by 90 degrees.



noise-free



noisy, PSNR: 29.98dB



BM3D: PSNR: **30.78** dB



our result: 30.15dB