

# Dictionary Learning and Denoising

Mathematical Models and Methods for Image  
Processing

Stefano Bertolasi

April 9th 2026

# Assignment 1: Implement the KSVD algorithm

- Extract random patches from an image (e.g., *barbara.png* and *cameraman.png*)
- Put the random patches to zero mean
- Randomly initialize the dictionary
- Use the KSVD algorithm to learn  $D$
- Start with few patches, the KSVD can be computationally expensive

Image cameraman.png



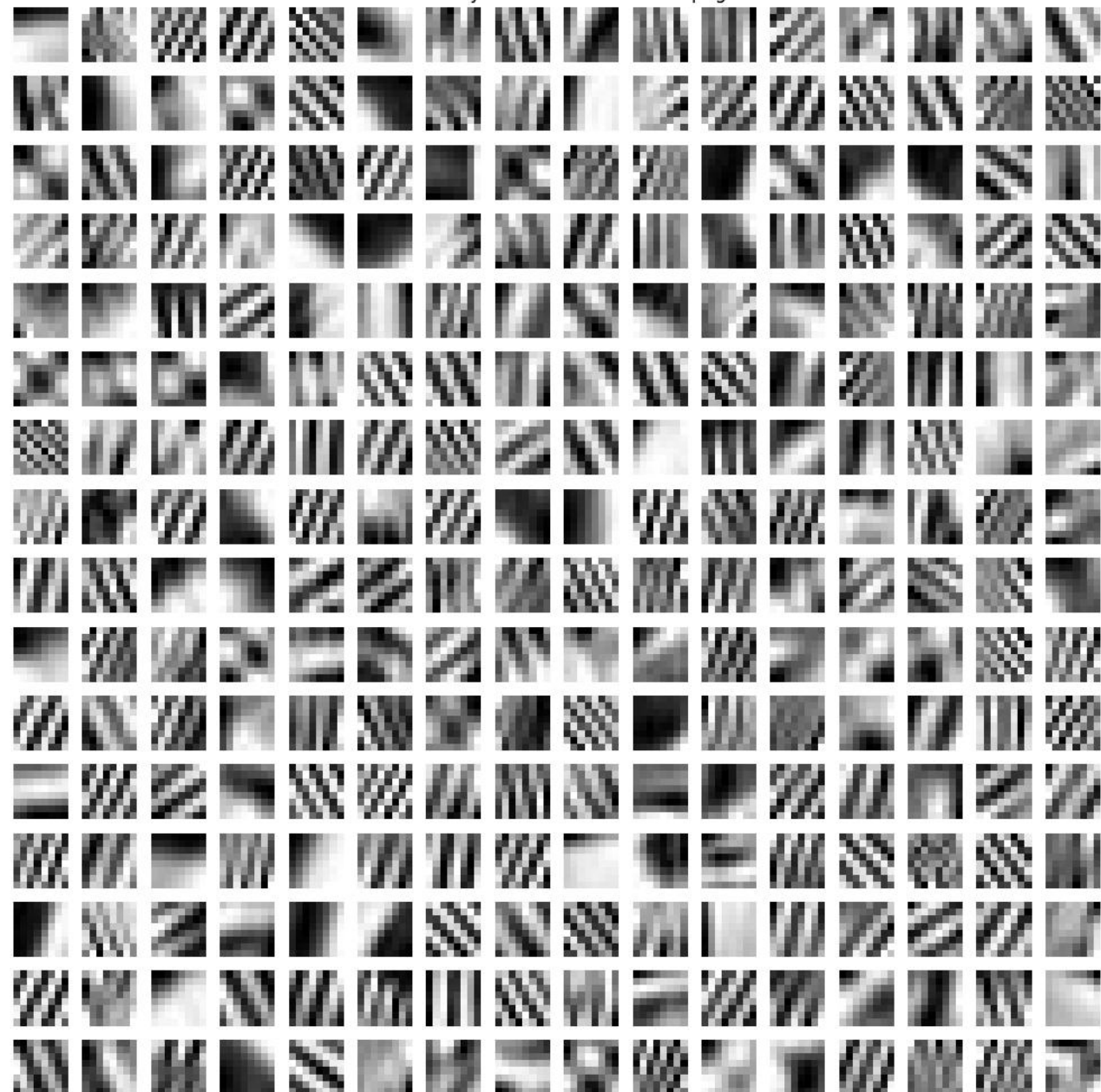
Dictionary learned from cameraman.png



Image barbara.png



Dictionary learned from barbara.png



# Assignment 2: Denoising with learned dictionaries

Denoise the image *barbara.png* with OMP using learned dictionaries

Original image (barbara.png)



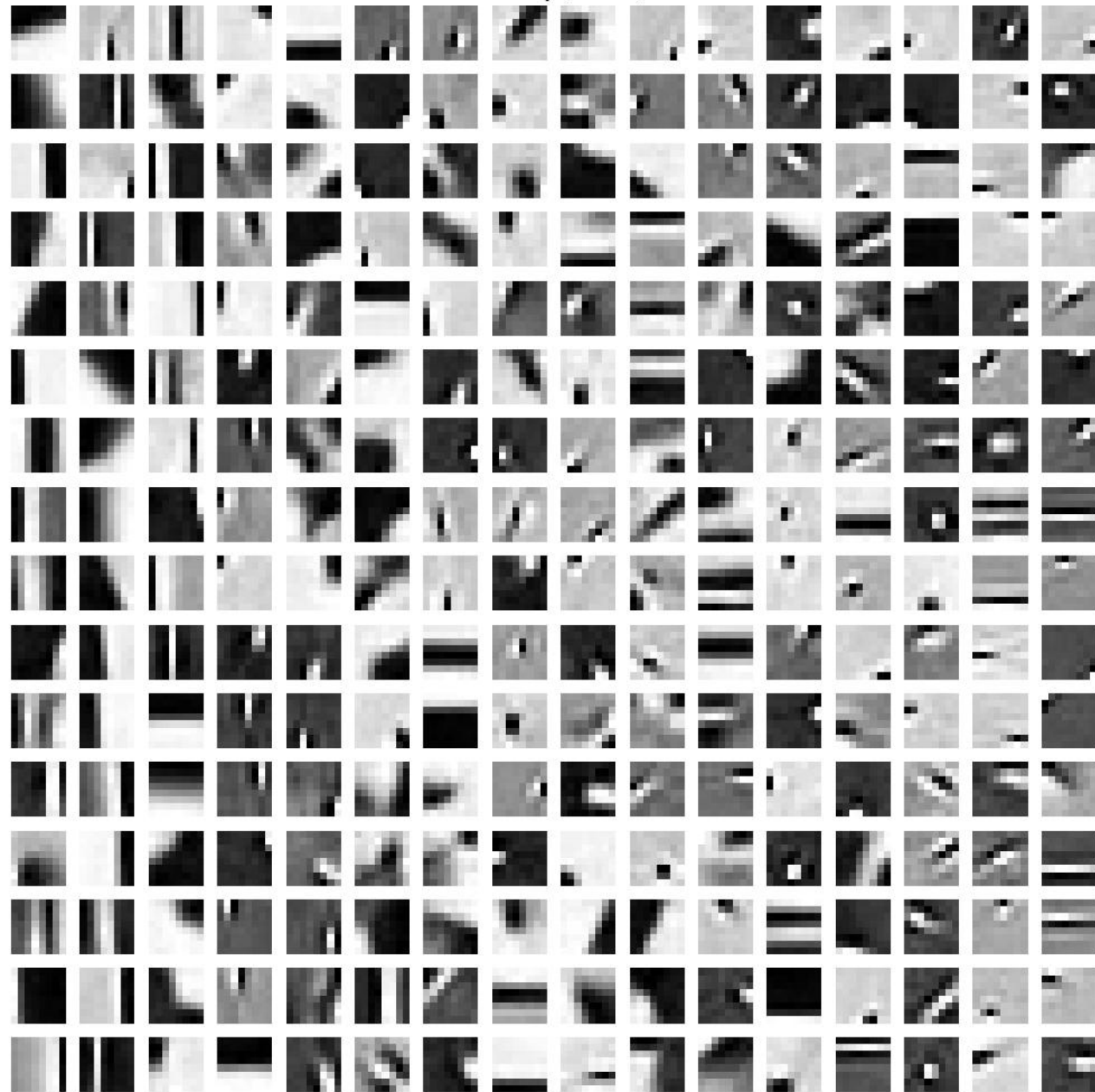
Noisy image, PSNR = 22.12



# Assignment 2: Denoising with learned dictionaries

- Learn distinct dictionaries:
  - $D_{diff}$  from a different image (e.g., *cameraman.png*)
  - $D_{noisy}$  from the noisy image
  - $D_{clean}$  from the clean image
- Perform OMP denoising using the generic dictionary of the previous assignment,  $D_{diff}$ ,  $D_{noisy}$  and  $D_{clean}$
- Compare the results

Dictionary (Generic)



Denosed image, PSNR = 27.68



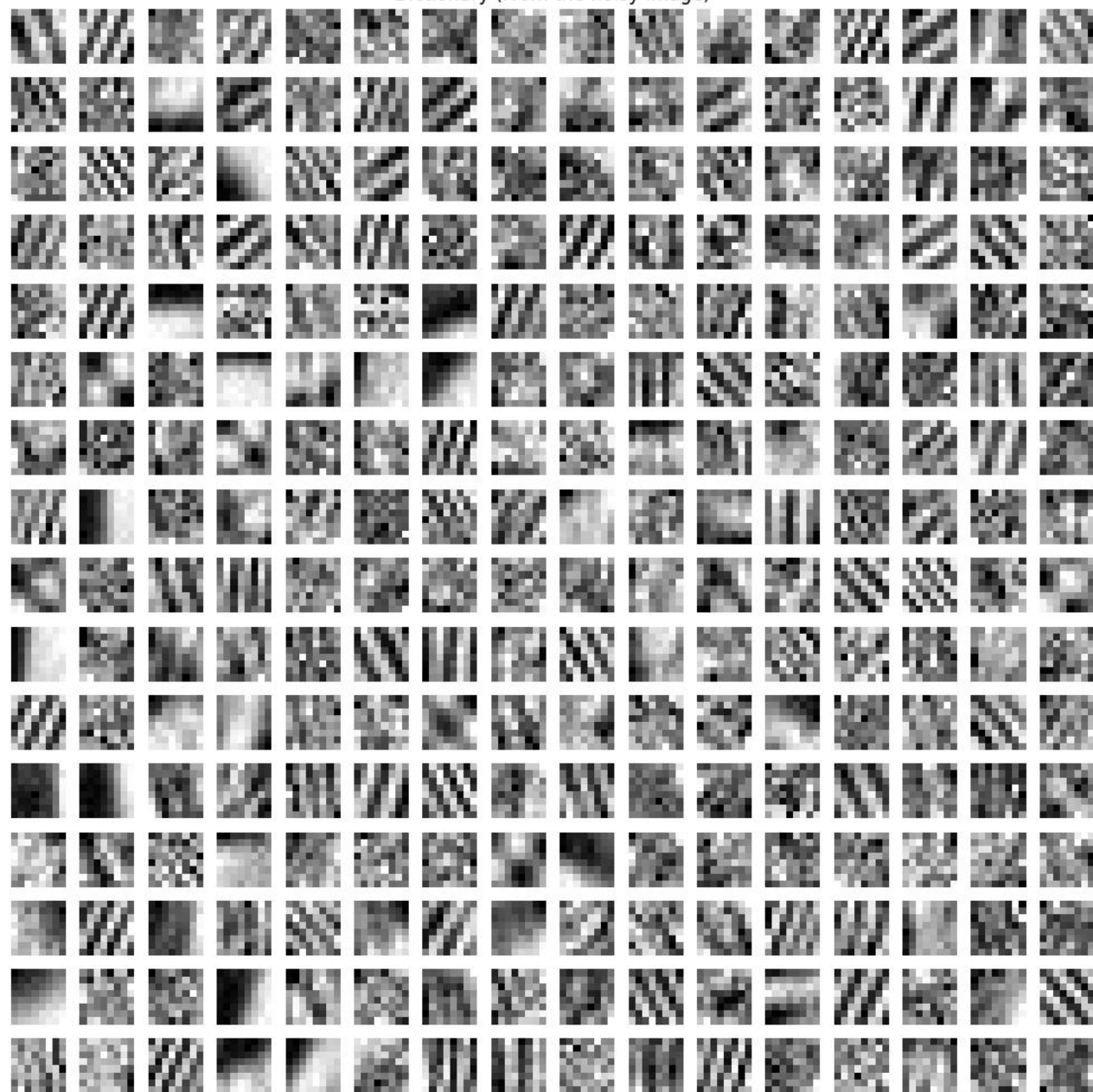
Dictionary (From a different image)



Denoised image, PSNR = 27.94



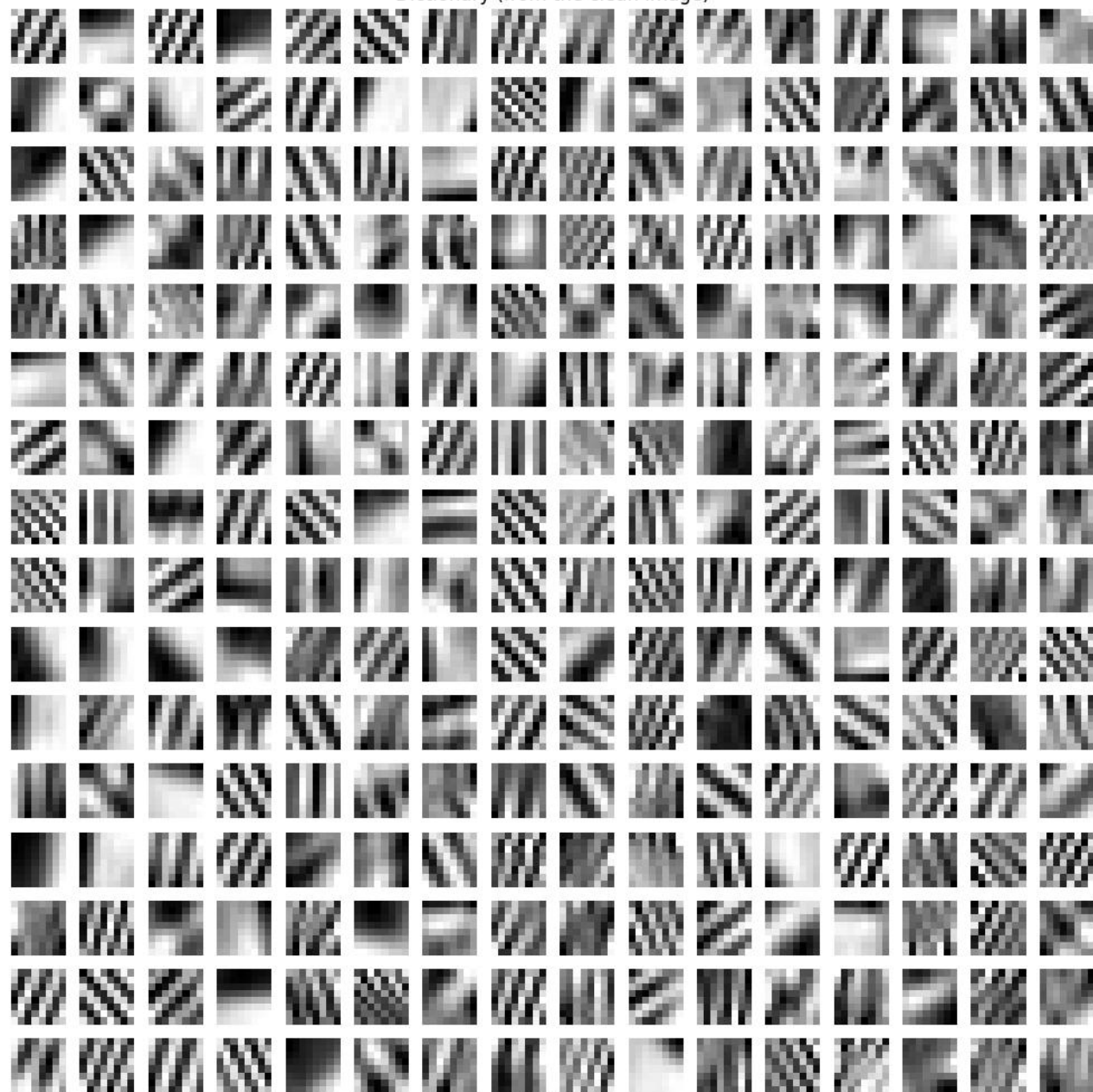
Dictionary (From the noisy image)



Denosed image, PSNR = 28.89



Dictionary (from the clean image)



Denosed image, PSNR = 29.39



# Extra Assignment 1: Learn textures

- Download few texture-rich images from the Brodatz dataset (<https://sipi.usc.edu/database/database.php>)
- Use KSVD to learn dictionaries from these images
- Try with different patch sizes

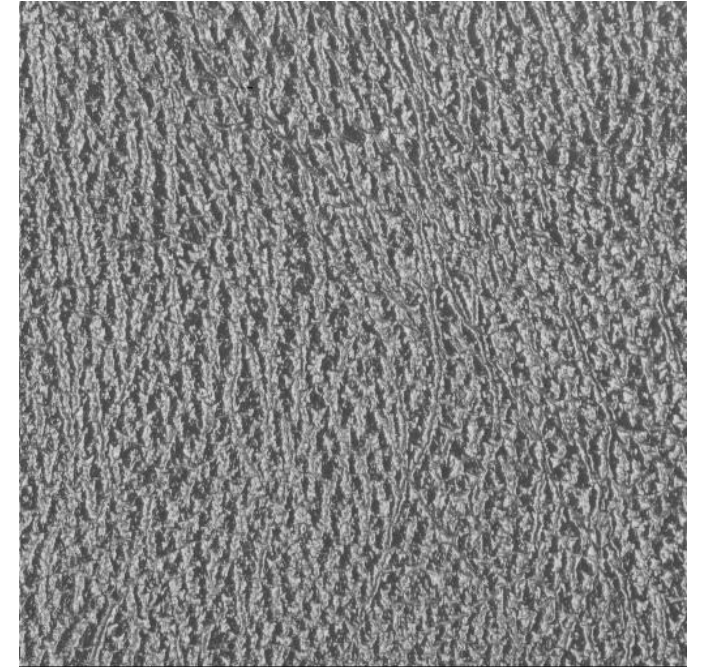
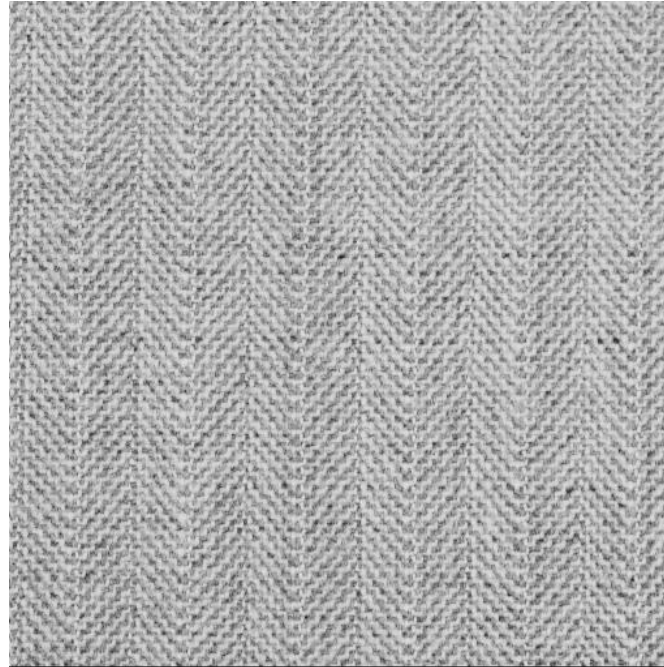
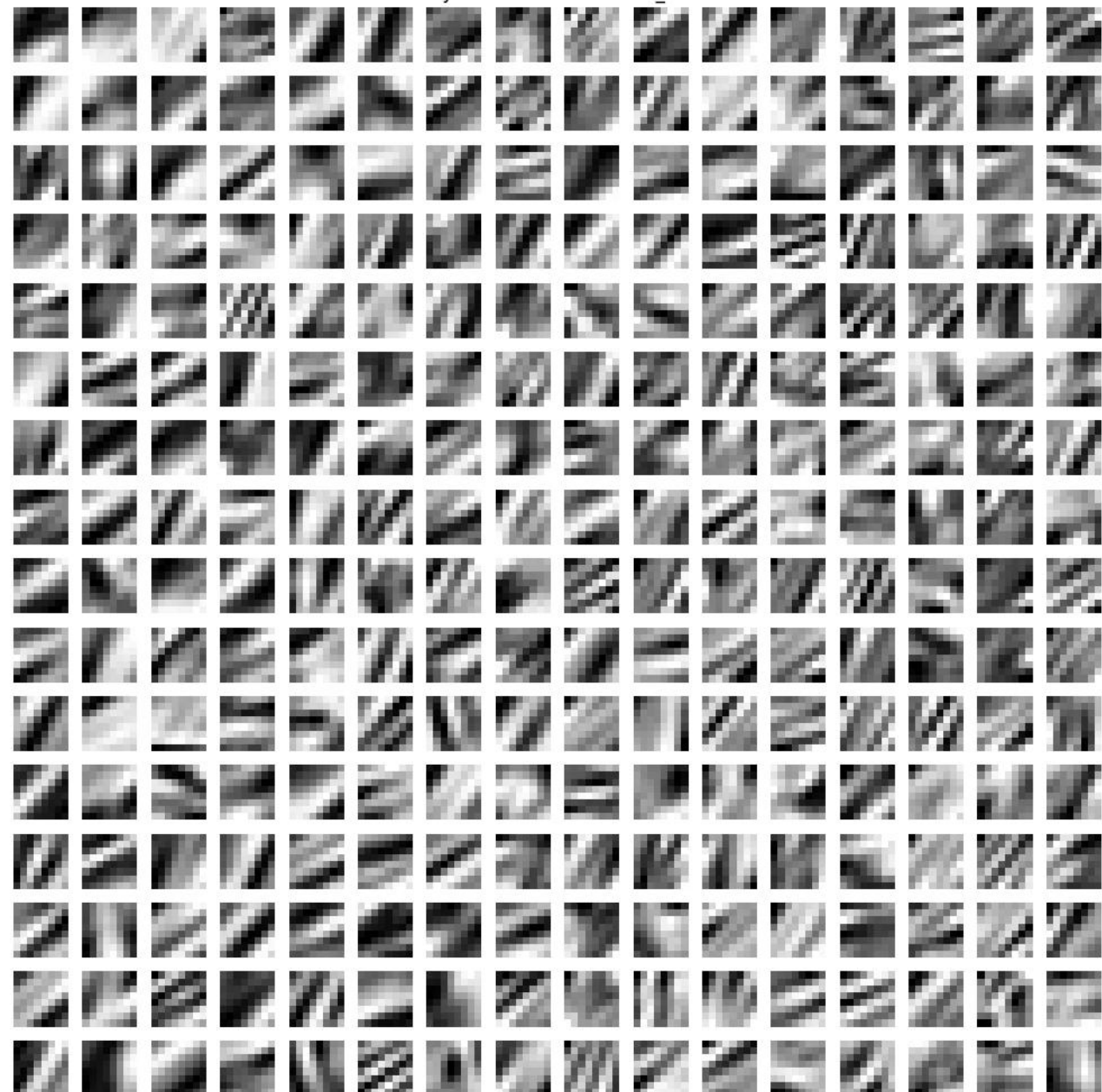


Image brodatz\_1.1.03.tiff



Dictionary learned from brodatz\_1.1.03.tiff

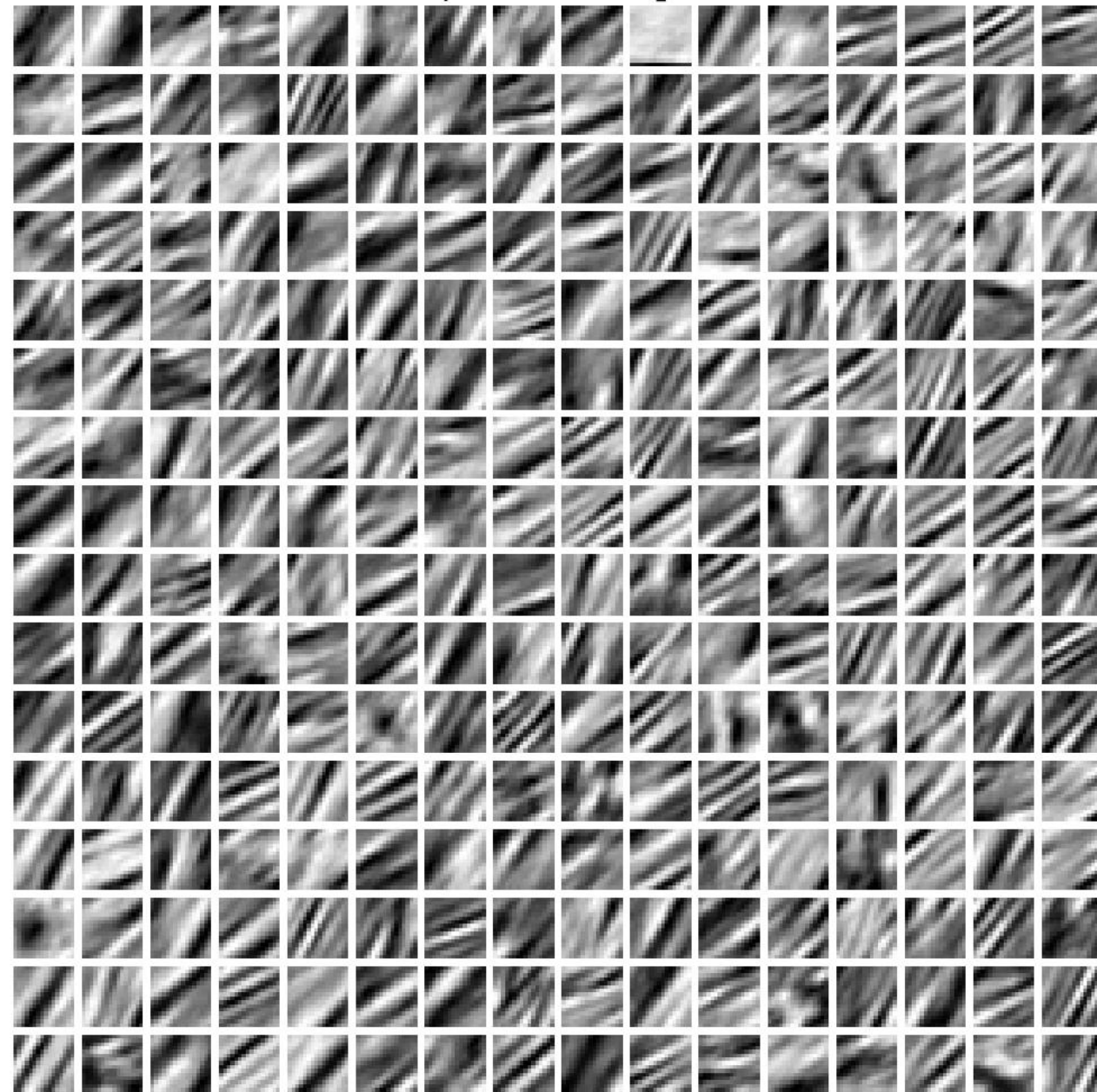


$p = 8$

Image brodatz\_1.1.03.tiff



Dictionary learned from brodatz\_1.1.03.tiff



$p = 16$