Medical Image Computing

Assignment 1

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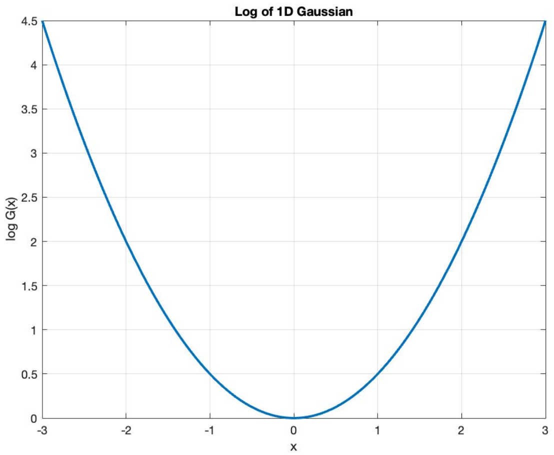
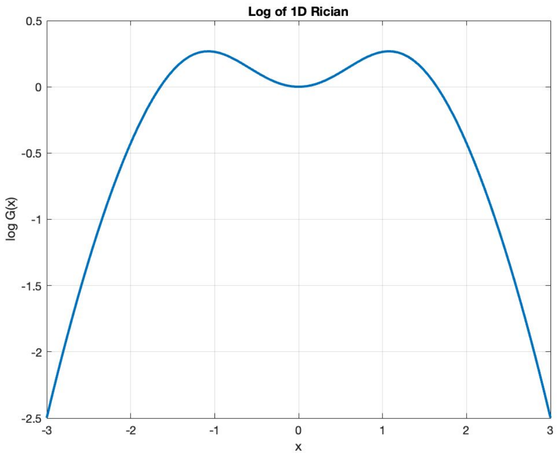
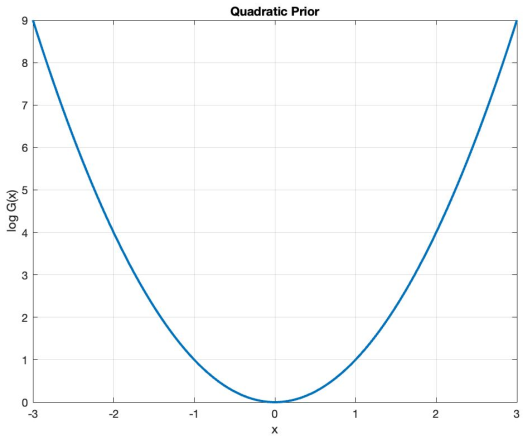
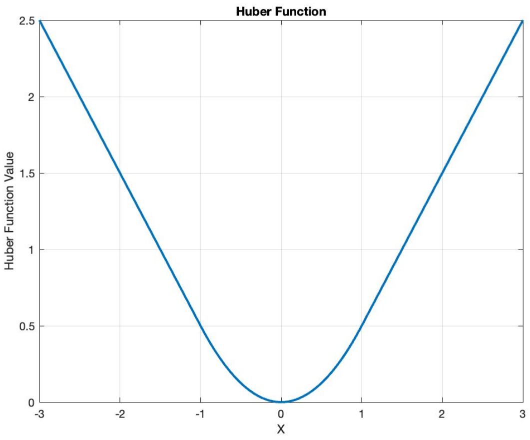
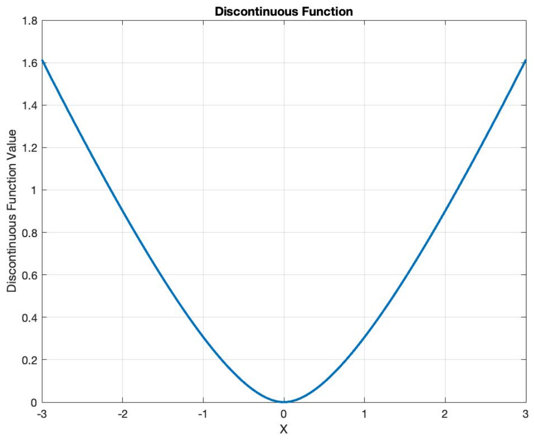
Q1 - Bayesian Denoising of a Phantom Magnetic Resonance Image

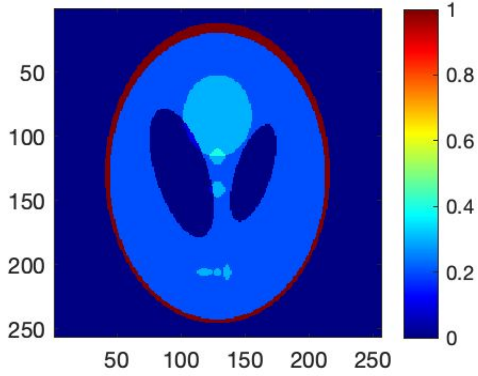
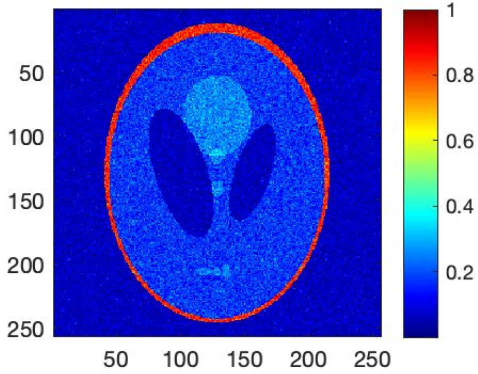
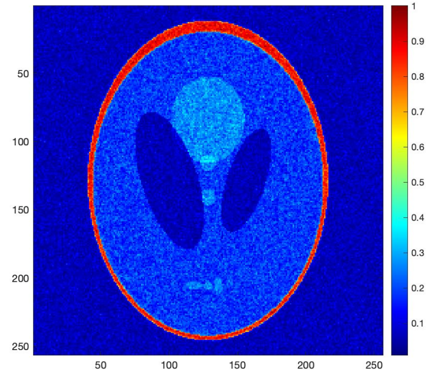
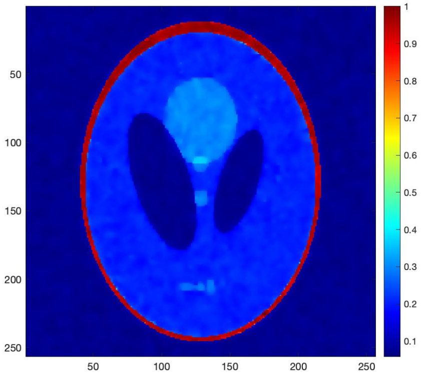
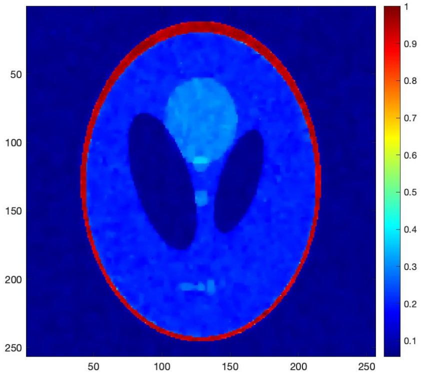
- ➔ Implemented both Gaussian and Rician Noise Model, and quadratic, discontinuous-adaptive Huber function, discontinuous-adaptive function

Gaussian	Rician
$$-log(G(X,Y)) = \sum_{x_i}(X-Y)^2$$	$$\log(R(X,Y)) = \sum_{x_i}(X^2+Y^2)/2 - \sum_{i} log(I_0(x_i y_i))$$
	

Quadratic prior	Discontinuity-adaptive Huber prior	Discontinuity-adaptive prior
		

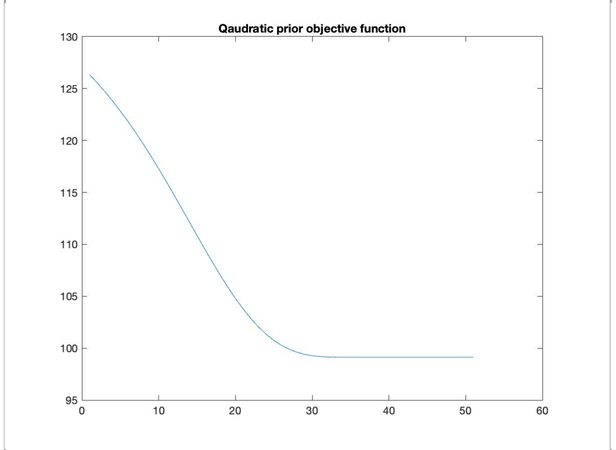
RRMSE(noisyImage, noiselessImage) = 0.3334

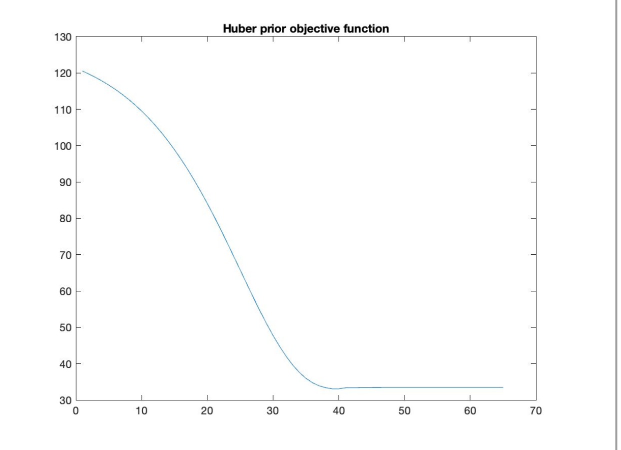
MRF Prior	Quadratic function	Discontinuity-Adaptive Huber function	Discontinuity-adaptive function
(α, γ)	(0.05, _)	(0.96, 0.01)	(0.97, 0.00512)
RRMSE(α, γ)	0.3159	0.2351	0.2375
RRMSE(min(1.2*α,1),γ)	0.3162	0.3365	0.2809
RRMSE(0.8*α, γ)	0.3168	0.2499	0.2700
RRMSE(α, 1.2*γ)	0.3159	0.2354	0.2378
RRMSE(α, 0.8*γ)	0.3159	0.2352	0.2387

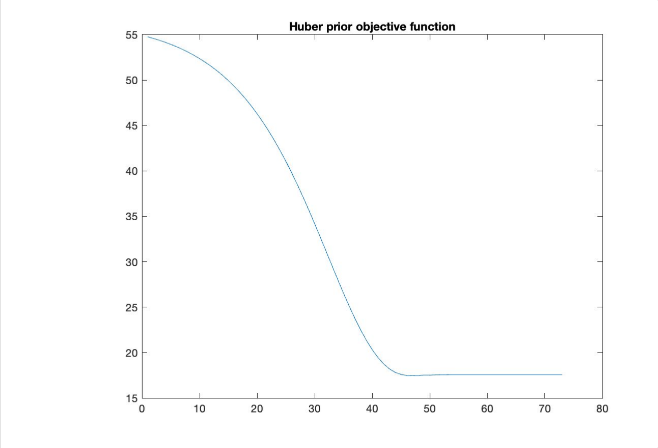
Noiseless	Noisy	Quadratic
		
DIscontinuity-adaptive Huber	Discontinuity-adaptive Function	
		

Noiseless	Noisy	Quadratic
		
DIscontinuity-adaptive Huber	Discontinuity-adaptive Function	
		

Quadratic	Discontinuity-Adaptive Huber	Discontinuity-Adaptive Function



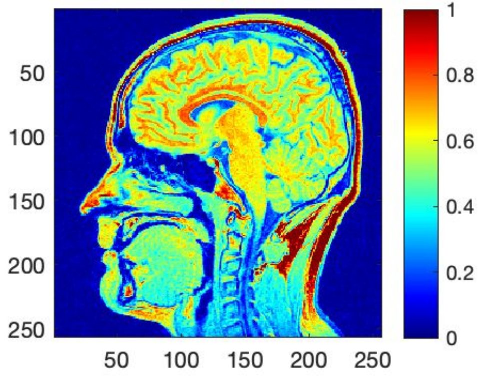
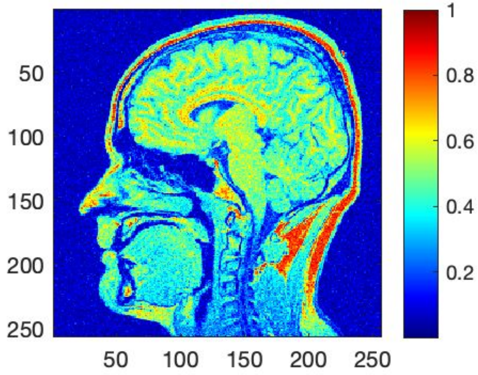
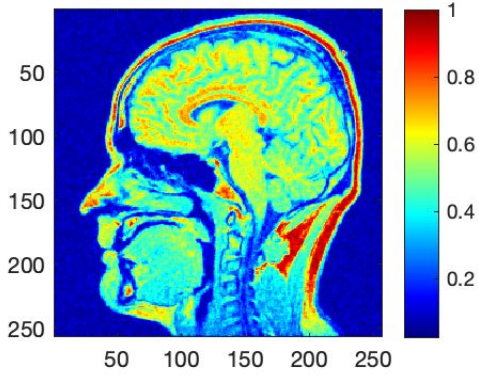
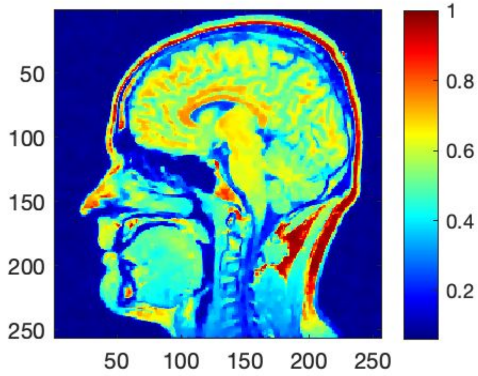
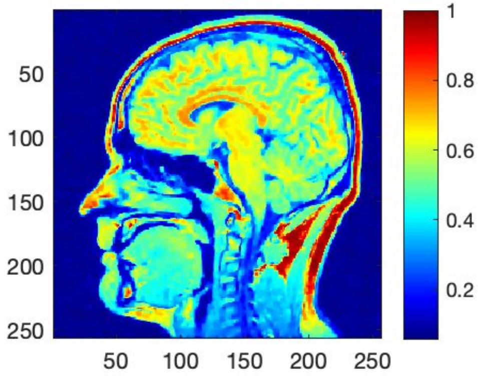


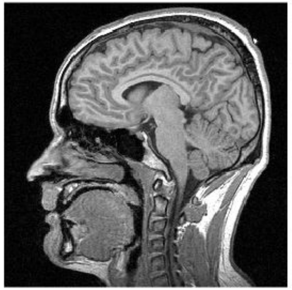
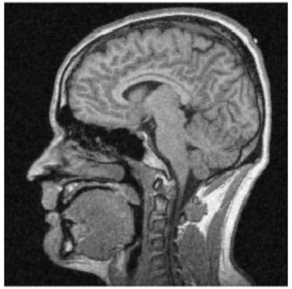
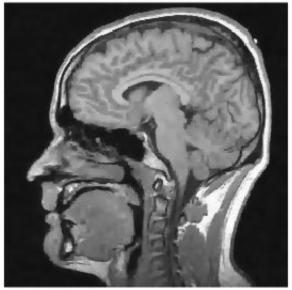
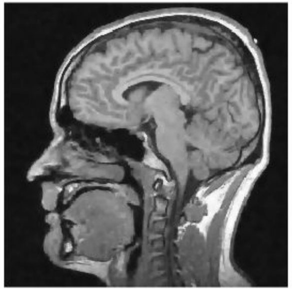


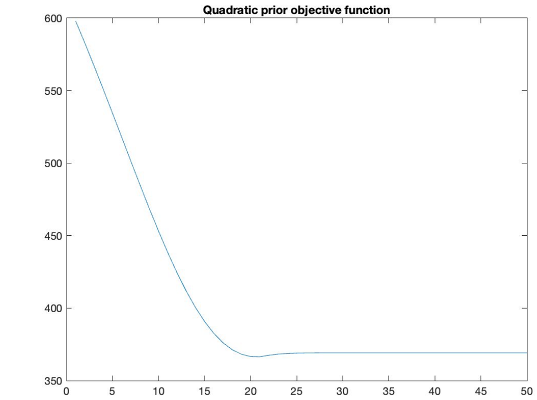
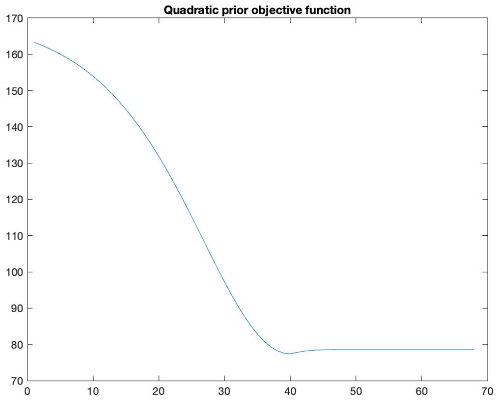
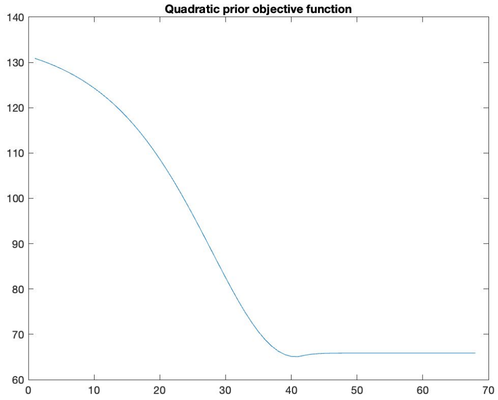
Q2 - **Bayesian Denoising of a Brain Magnetic Resonance Image**

RRMSE(noisyImage, noiselessImage) = 0.2373

MRF Prior	Quadratic function	Discontinuity-Adaptive Huber function	Discontinuity-adaptive function
(α, γ)	(0.23, _)	(0.95, 0.01)	(0.95, 0.01)
RRMSE(α, γ)	0.1545	0.1316	0.1316
RRMSE(min(1.2*α,1),γ)	0.1656	0.2649	0.2724
RRMSE(0.8*α, γ)	0.1594	0.1660	0.1696
RRMSE(α, 1.2*γ)	0.1545	0.1317	0.1320
RRMSE(α, 0.8*γ)	0.1545	0.1338	0.1330

Noiseless	Noisy	Quadratic
		
DIscontinuity-adaptive Huber	Discontinuity-adaptive Function	
		

Noiseless	Noisy	Quadratic
		
DIscontinuity-adaptive Huber	Discontinuity-adaptive Function	
		

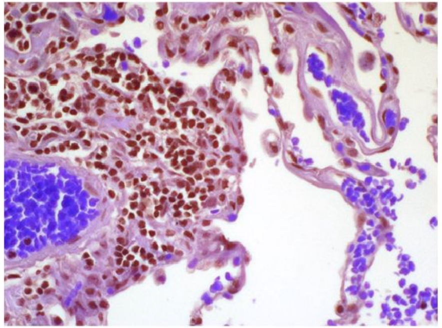
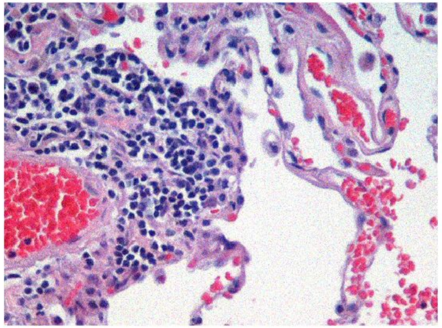
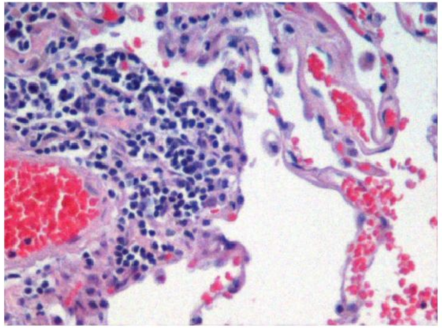
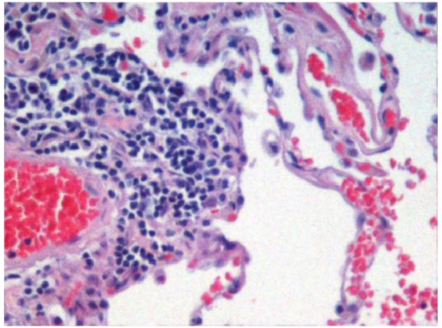
Quadratic	Discontinuity-Adaptive Huber	Discontinuity-Adaptive Function
		

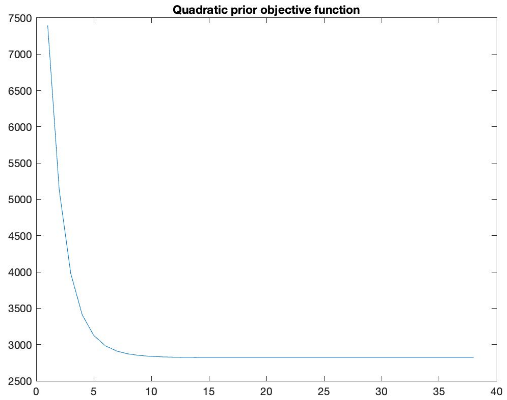
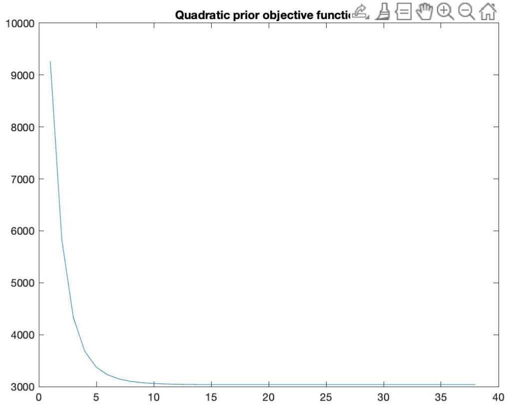
Q3 - **Bayesian Denoising of a RGB Microscopy Image**

RRMSE(noisyImage, noiselessImage) = 0.1899

MRF Prior	Prior A	Prior B	Prior C
(α, γ)	(0.23, _)	(0.28, _)	(_, _)
RRMSE(α, γ)	0.1722	0.1731	_
RRMSE(min(1.2*α,1),γ)	0.1723	0.1740	_
RRMSE(0.8*α, γ)	0.1728	0.1753	_
RRMSE(α, 1.2*γ)	0.1722	0.1731	_
RRMSE(α, 0.8*γ)	0.1722	0.1731	_

Implemented Priors A, B, C successfully, but the gradients of only A, B

Noiseless	Noisy	A
		
B	C	
		

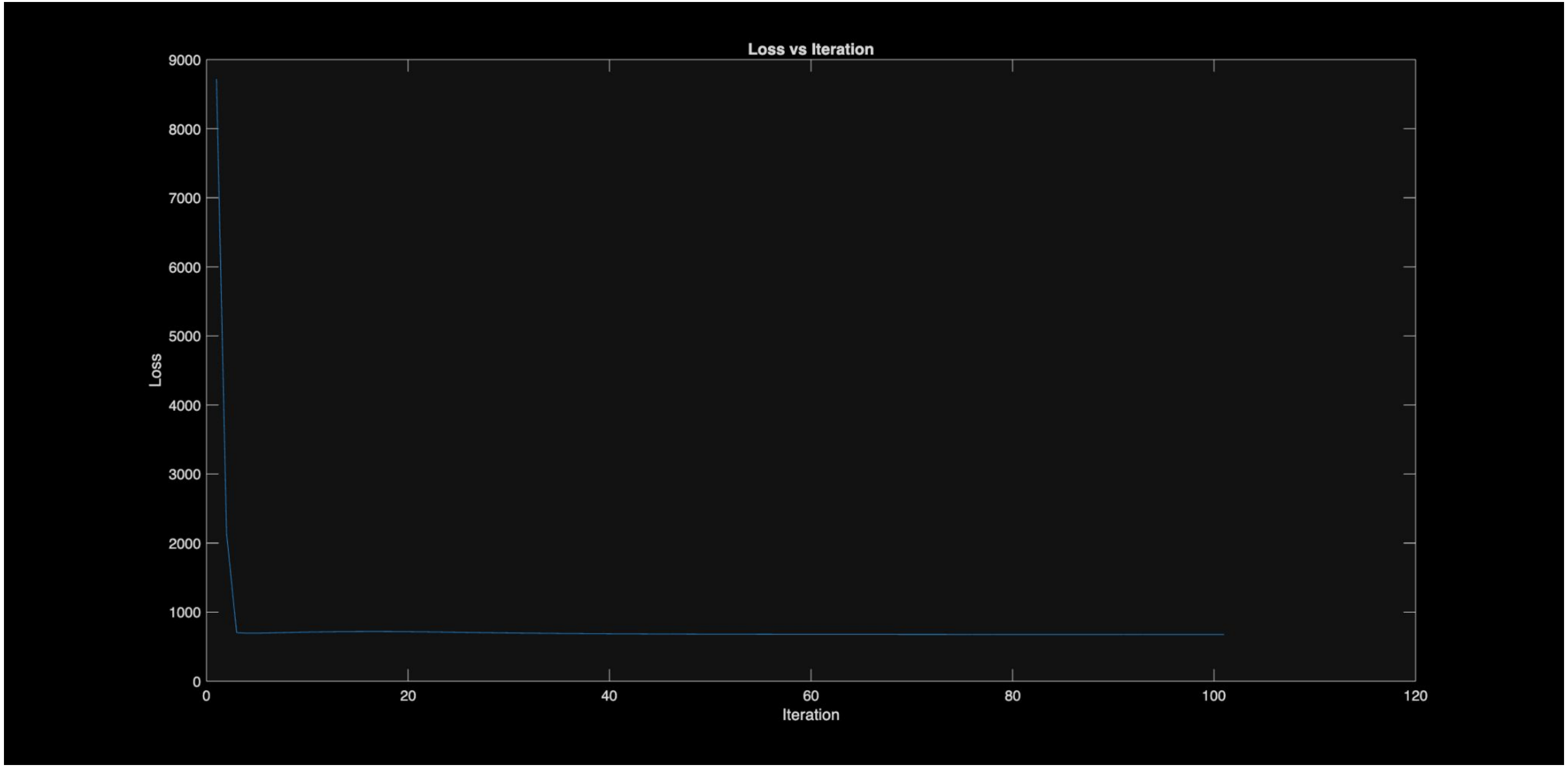
A	B	C
		

Q4: Dictionary Learning on Image Patches, Followed by Image Denoising.

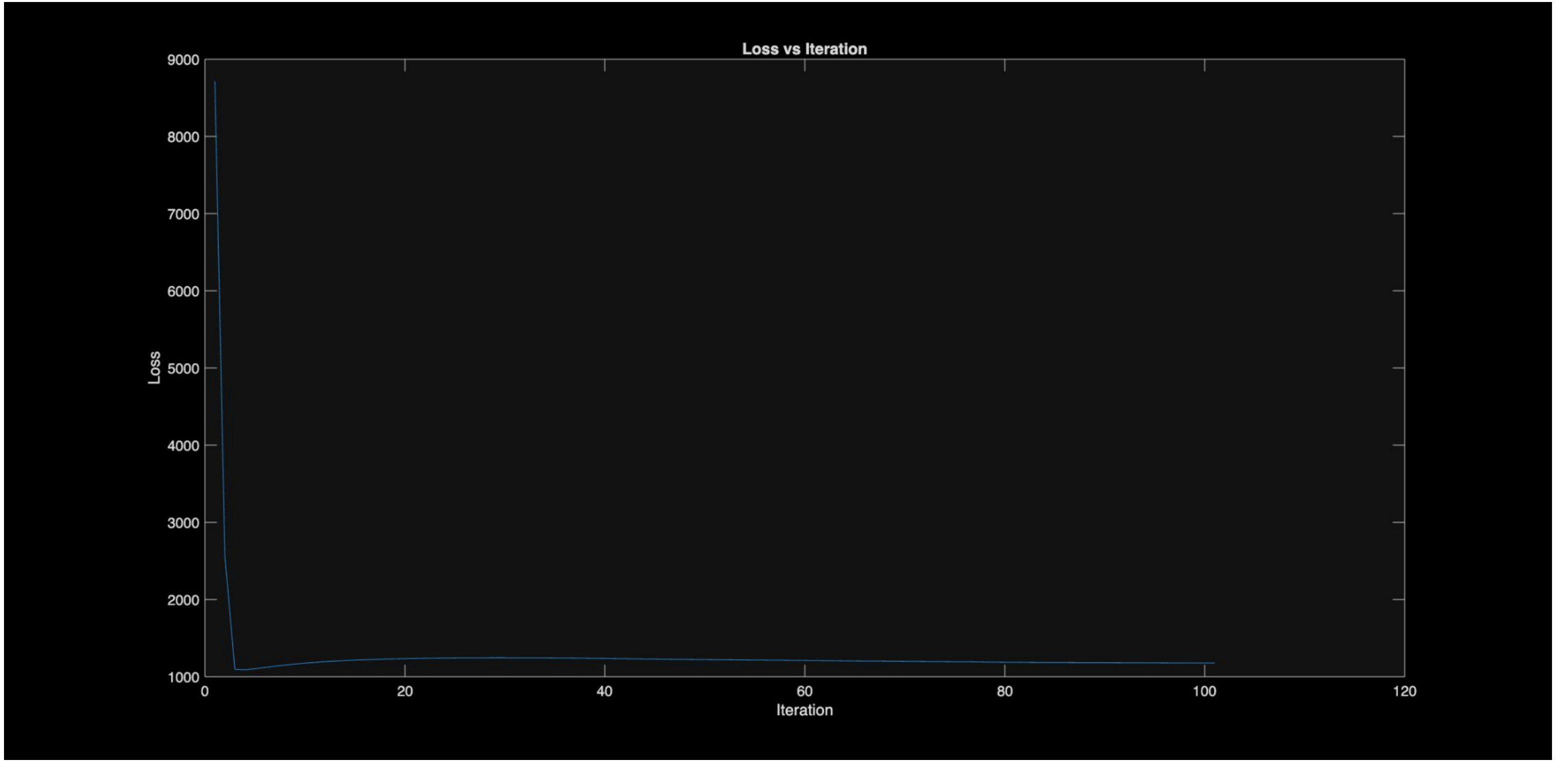
Strategy for selection of patches:

Out of all patches, choose those patches with variance greater than a threshold. Choose threshold such that there are a good number of patches.

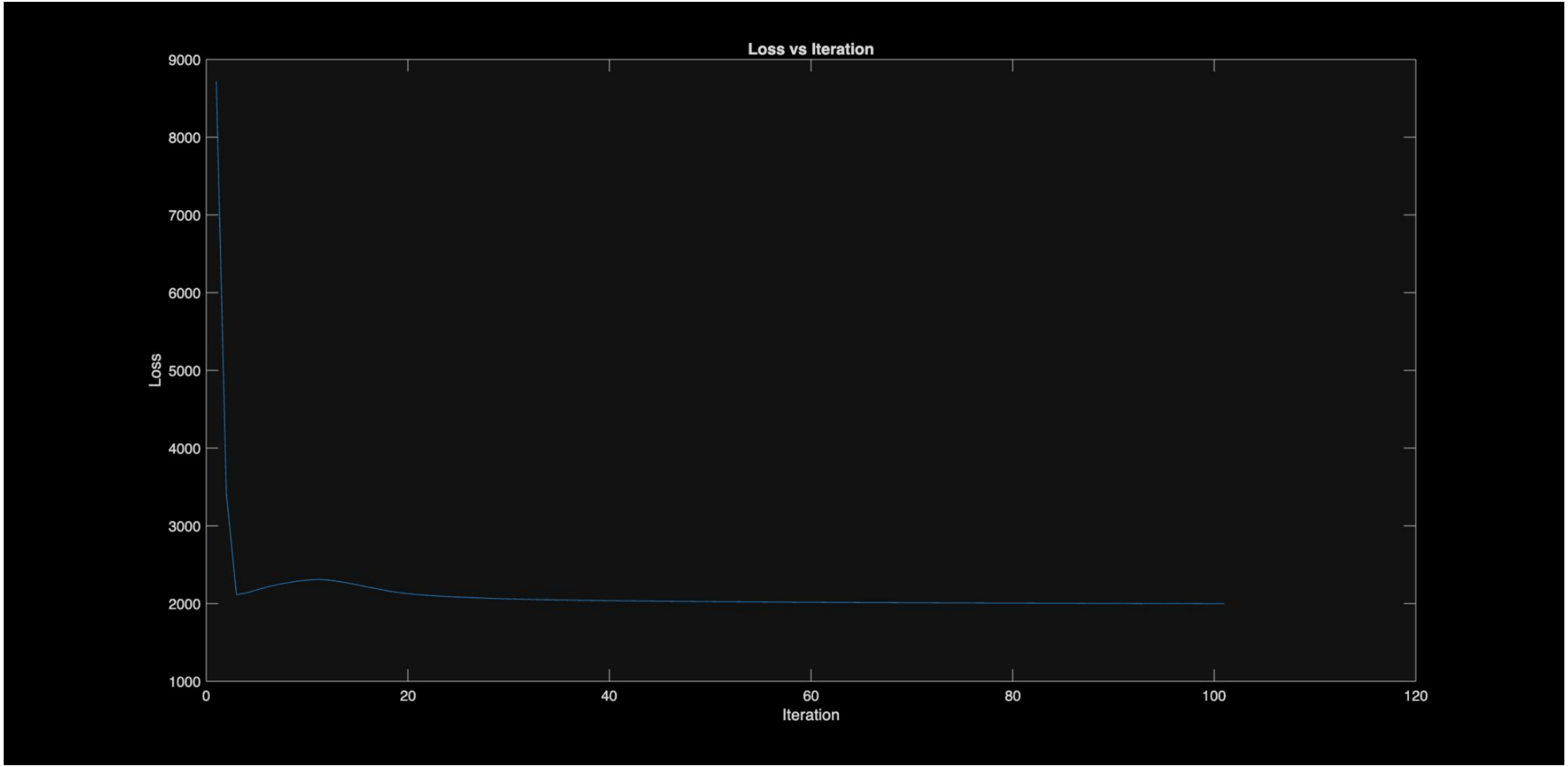
Objective function vs Iterations (p = 2)



Objective function vs Iterations (p = 1.6)

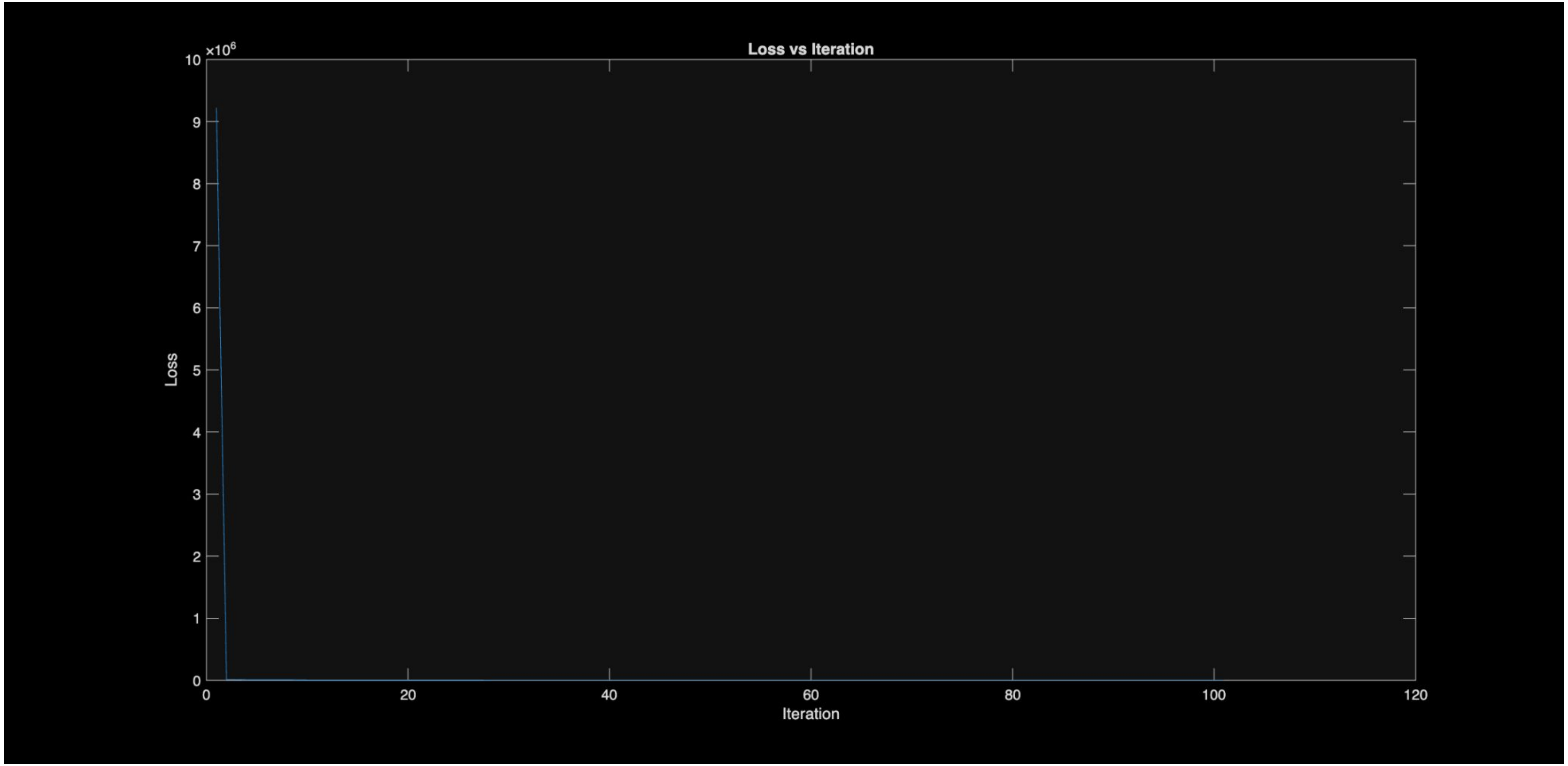


Objective function vs Iterations (p = 1.2)



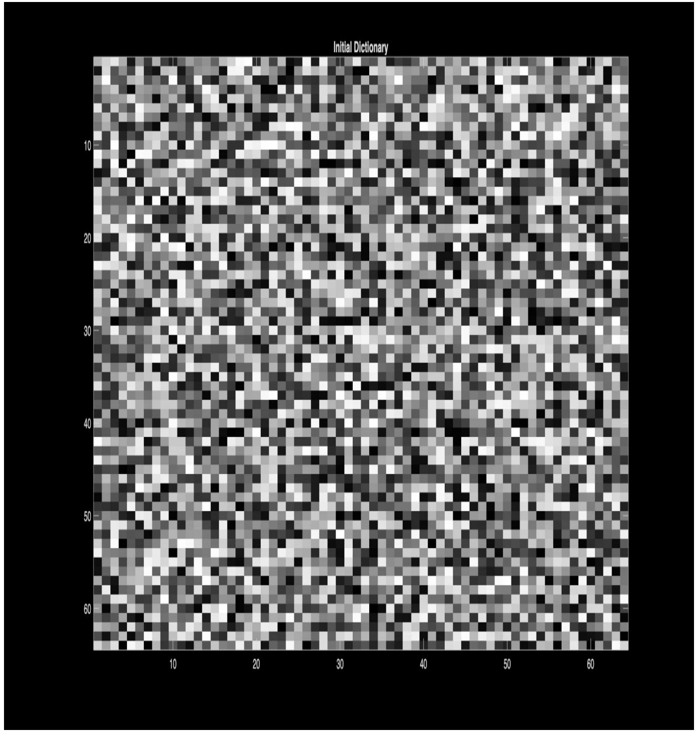
Objective function vs Iterations (p = 0.8)

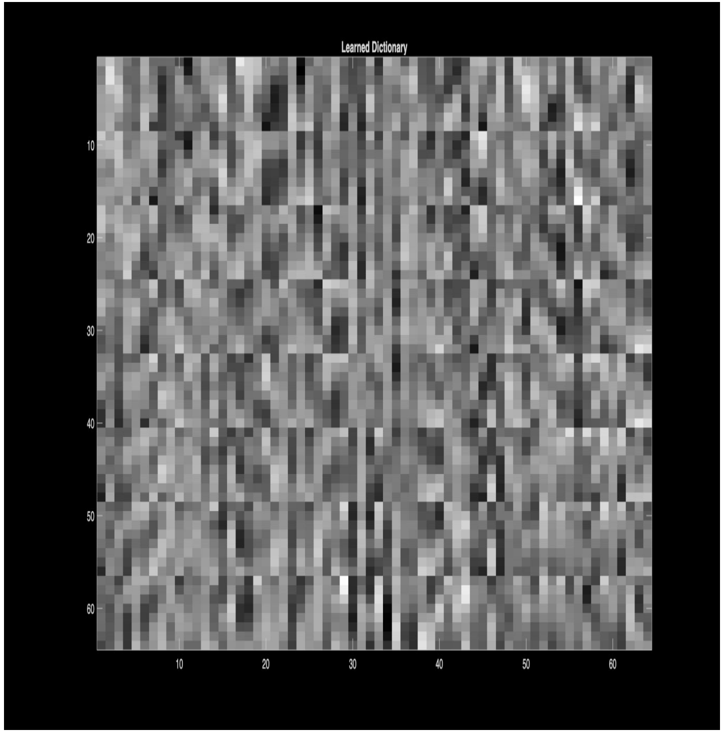
Loss drops down to upto 2500



Initial D vs Learned D (p = 2)

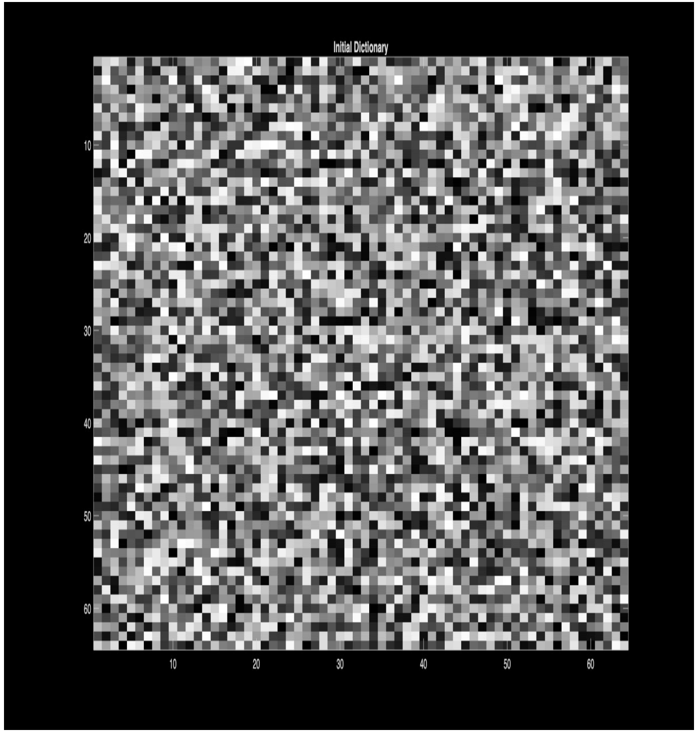
smooth

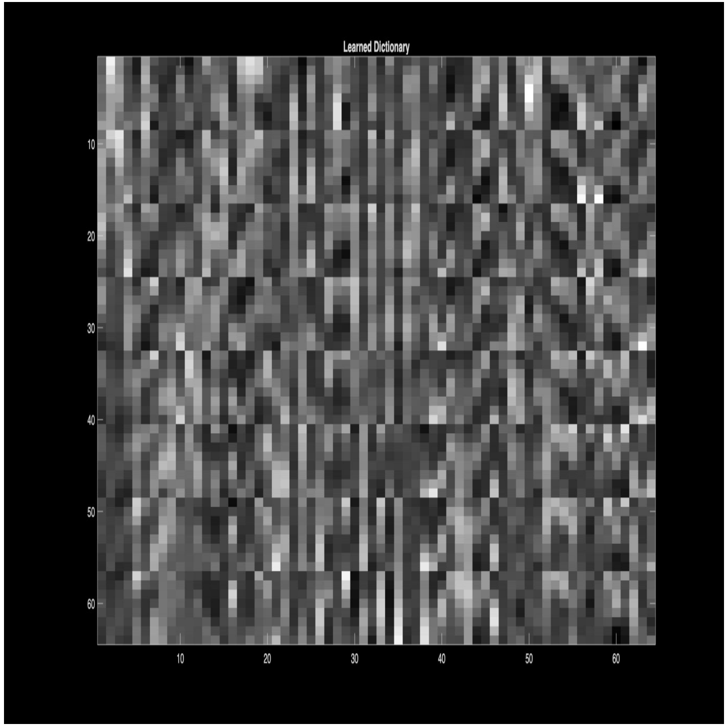




Initial D vs Learned D (p = 1.6)

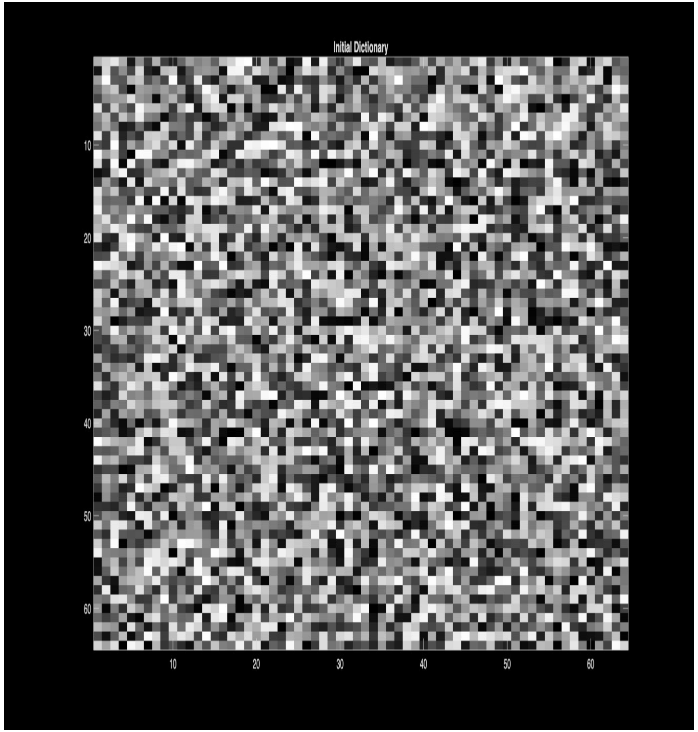
less smooth

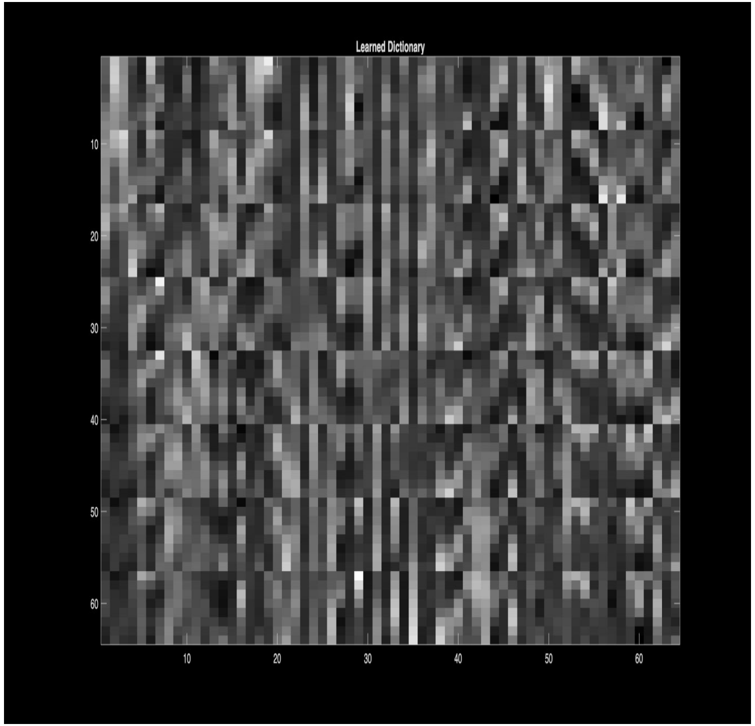




Initial D vs Learned D (p = 1.2)

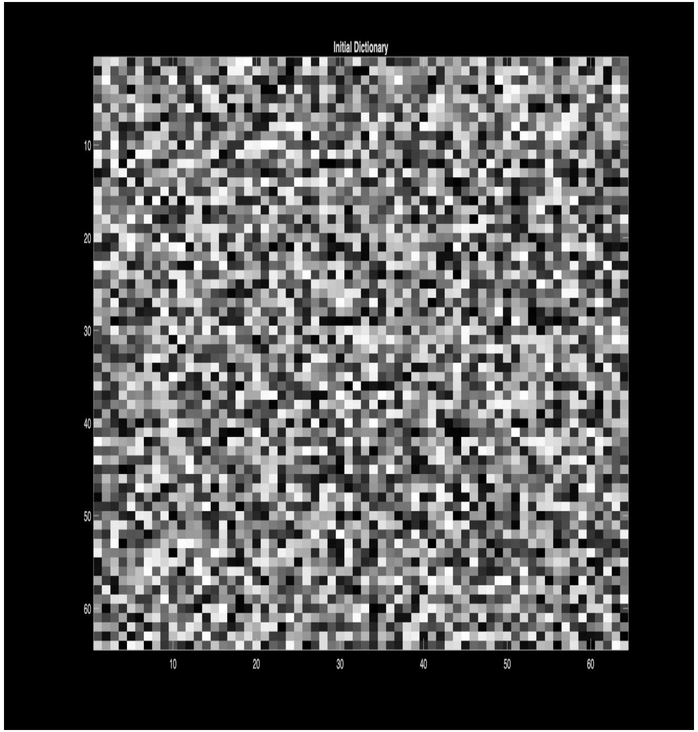
lesser smooth

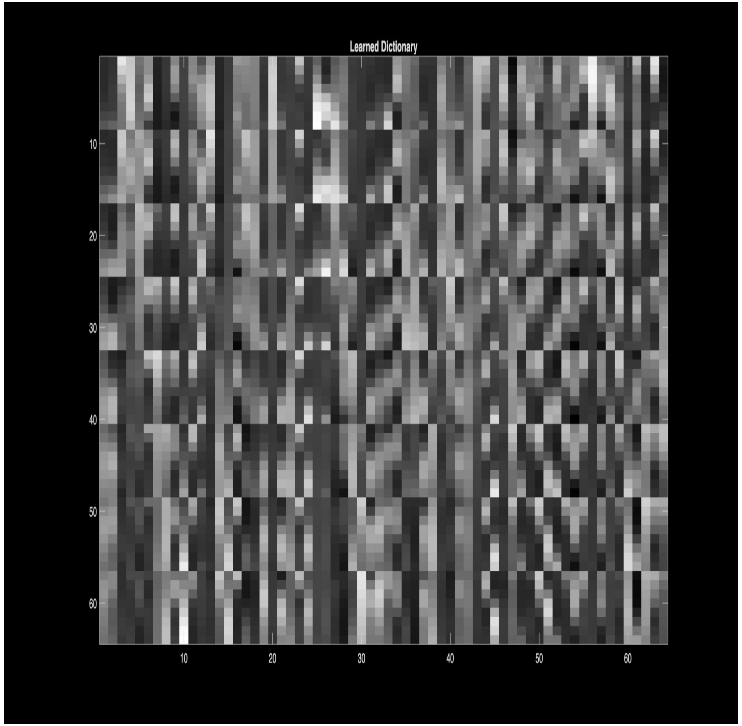




Initial D vs Learned D (p = 0.8)

least smooth

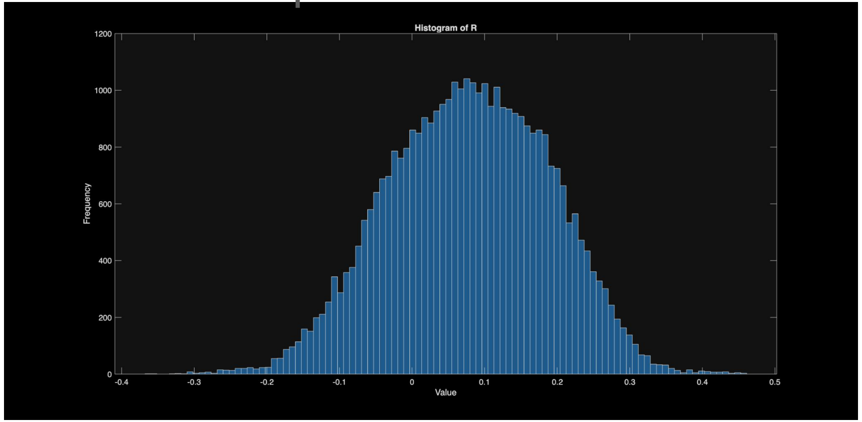




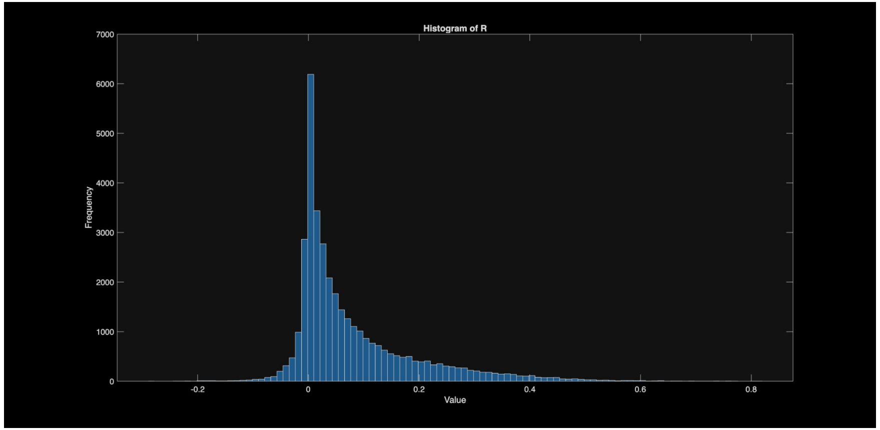
Histograms

lesser the value of p, greater the frequency near zero
Since smaller p denotes higher sparsity

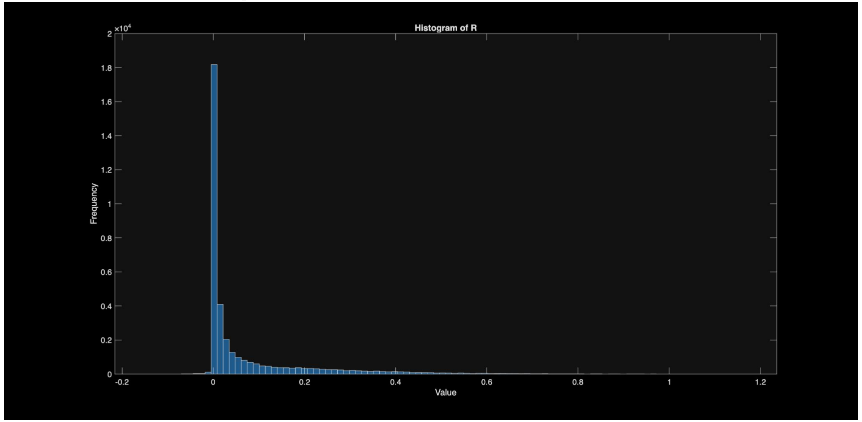
p=2



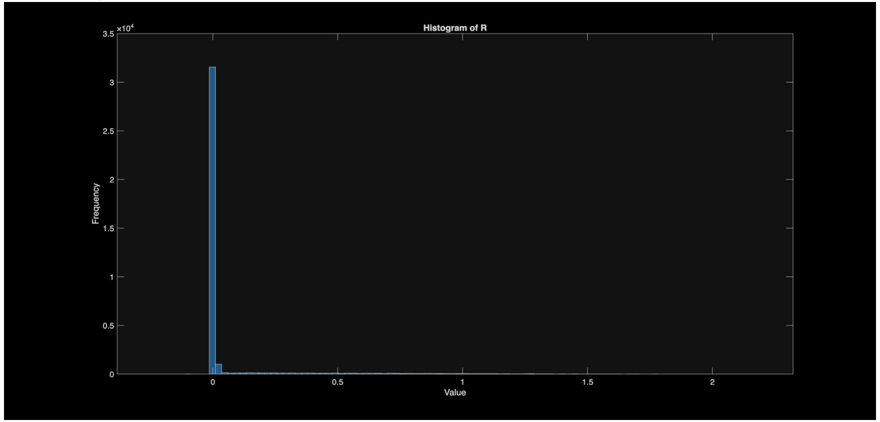
p=1.6



p=1.2

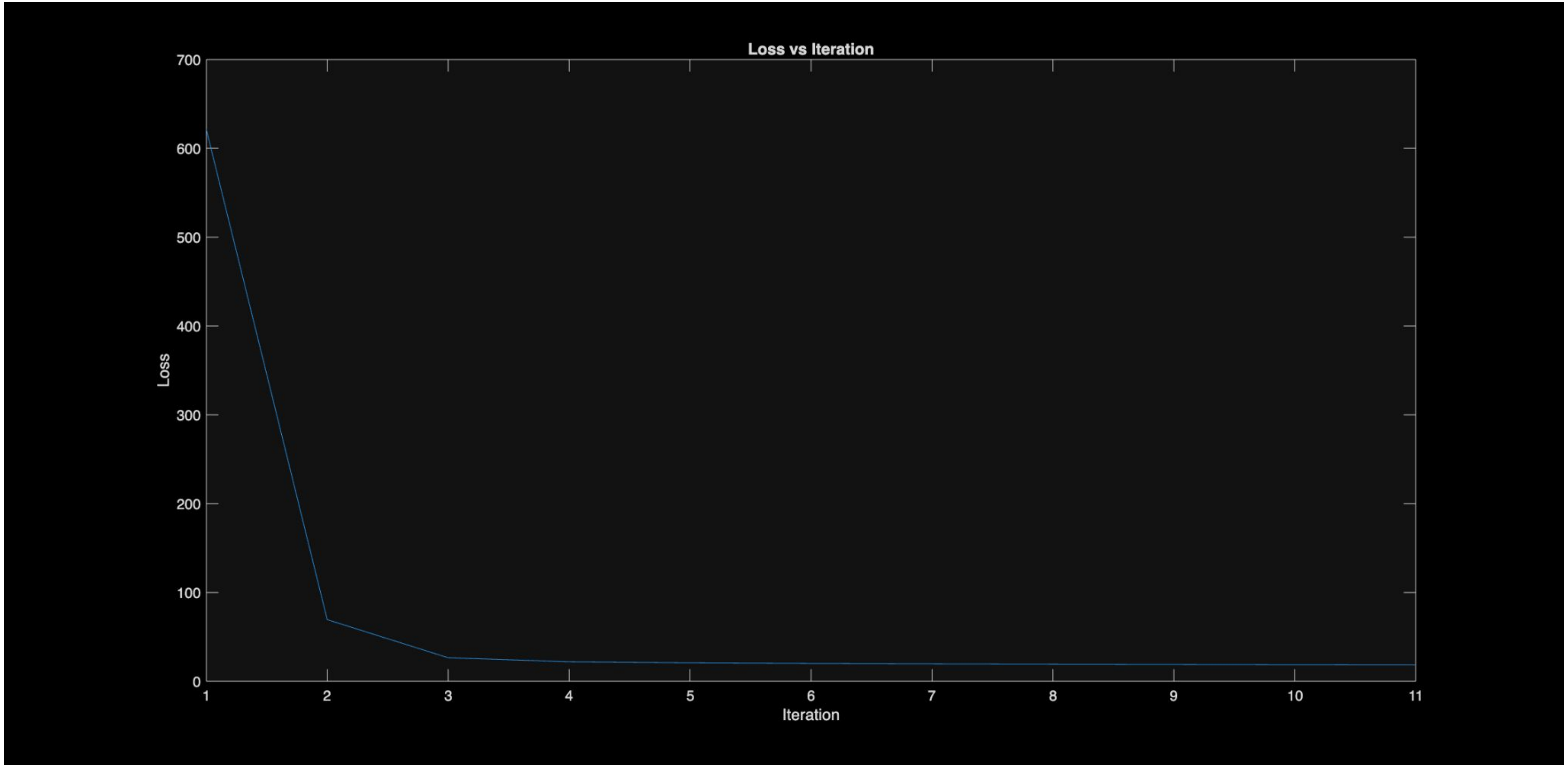


p=0.8



Loss vs Iteration for denoising

$$\min_r \sum_{i=1}^{I} \|x_i - Dr_i\|_2^2 + \lambda \|r_i\|_p^p$$



Original, noisy and denoised images