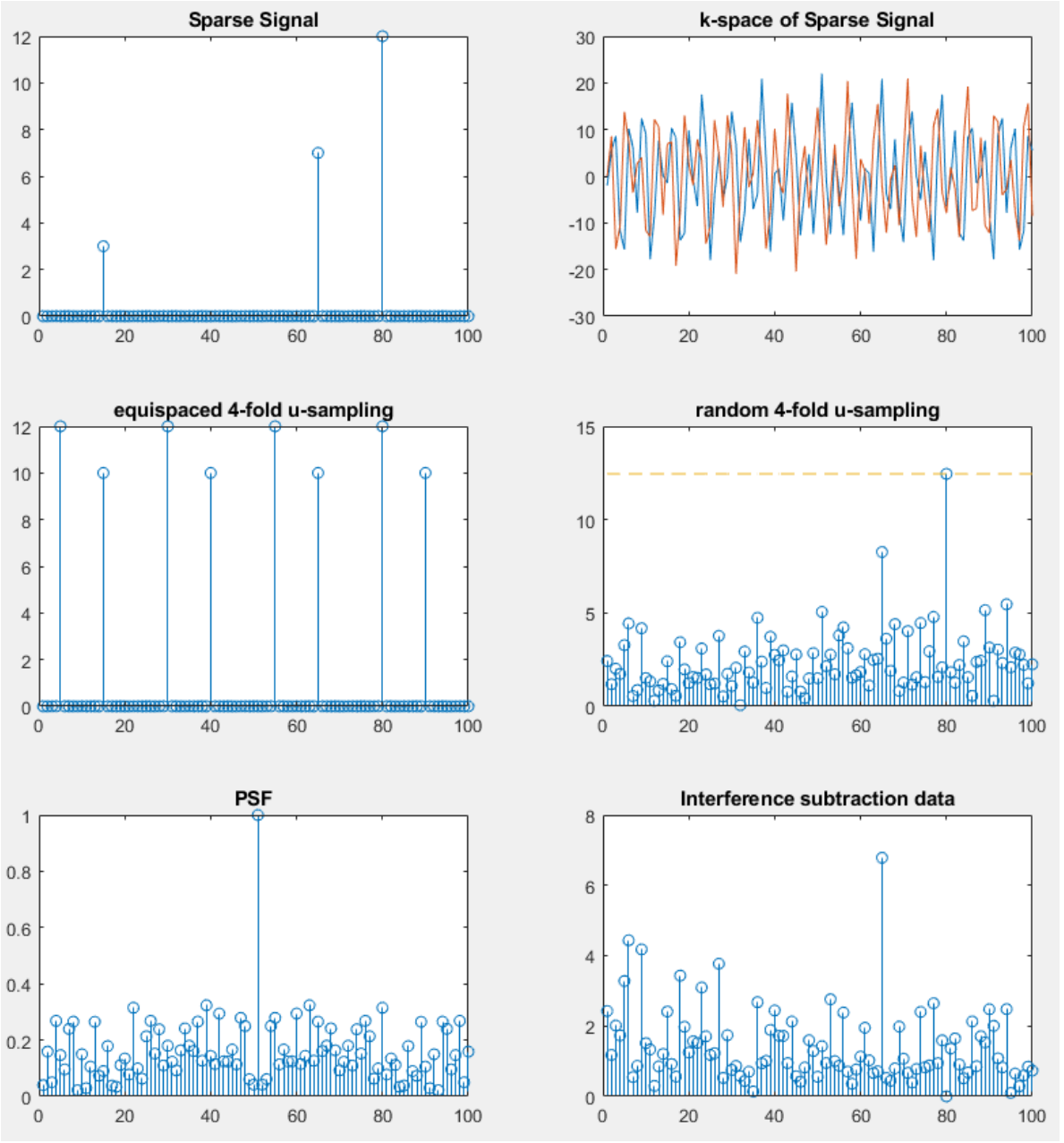
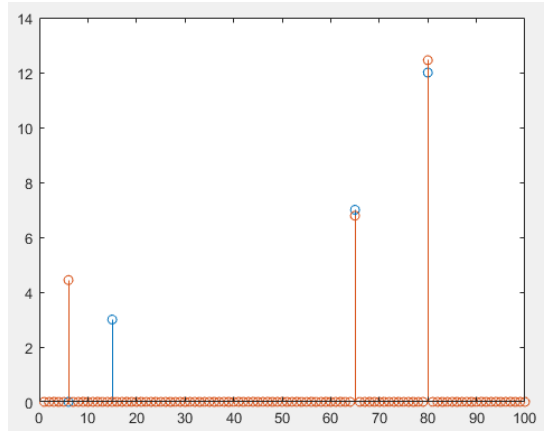
Sparse MRI:

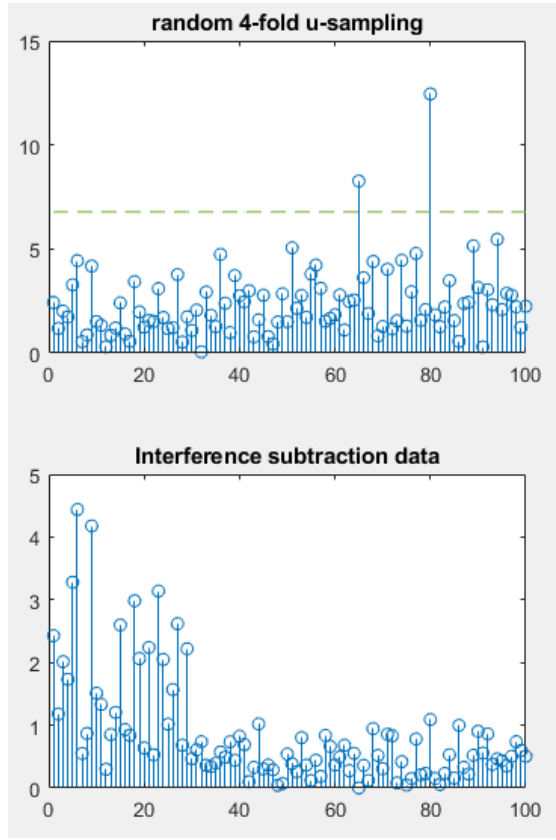
The Application of Compresses Sensing for Rapid MR Imaging

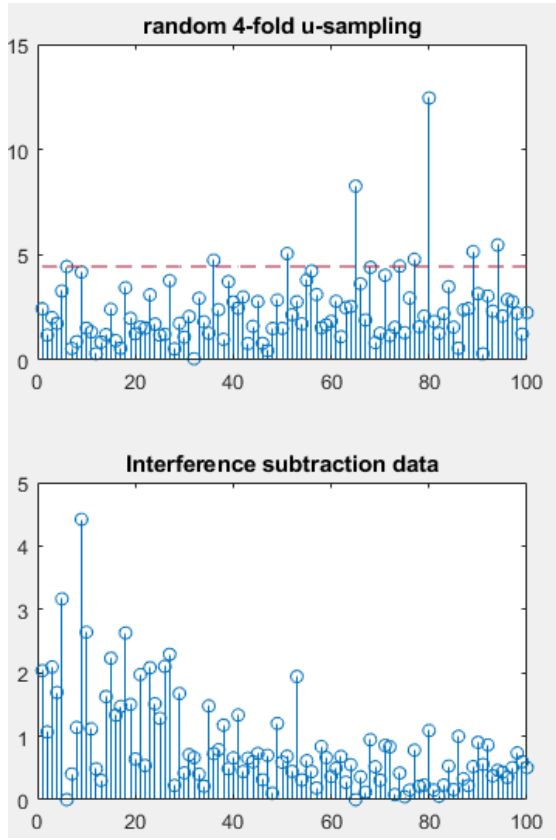
1.
Figures

1.1. Figure 2


Sparse Signal
k-space of Sparse Signal
equispaced 4-fold u-sampling
random 4-fold u-sampling
PSF
Interference subtraction data

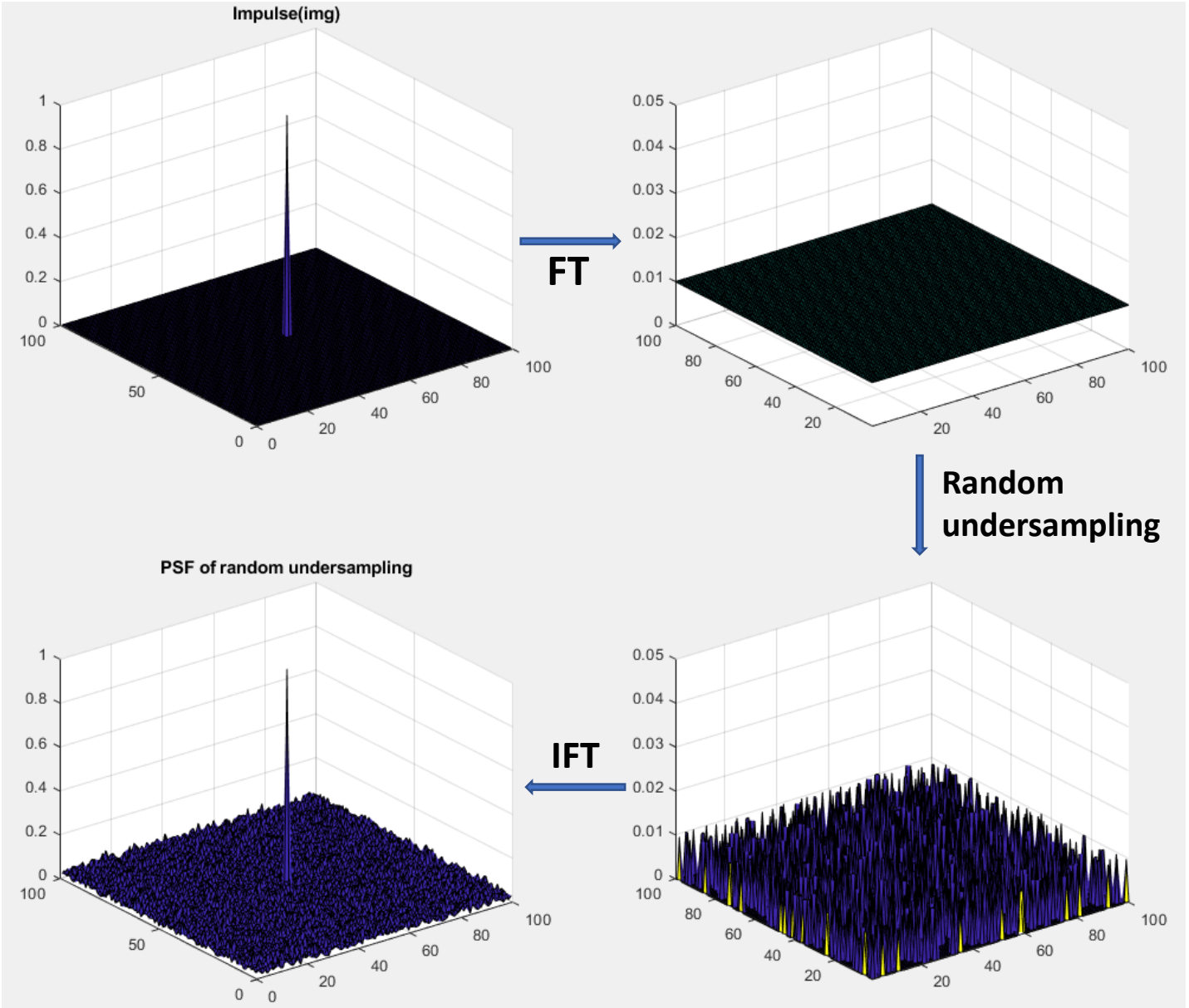



random 4-fold u-sampling
Interference subtraction data


random 4-fold u-sampling
Interference subtraction data

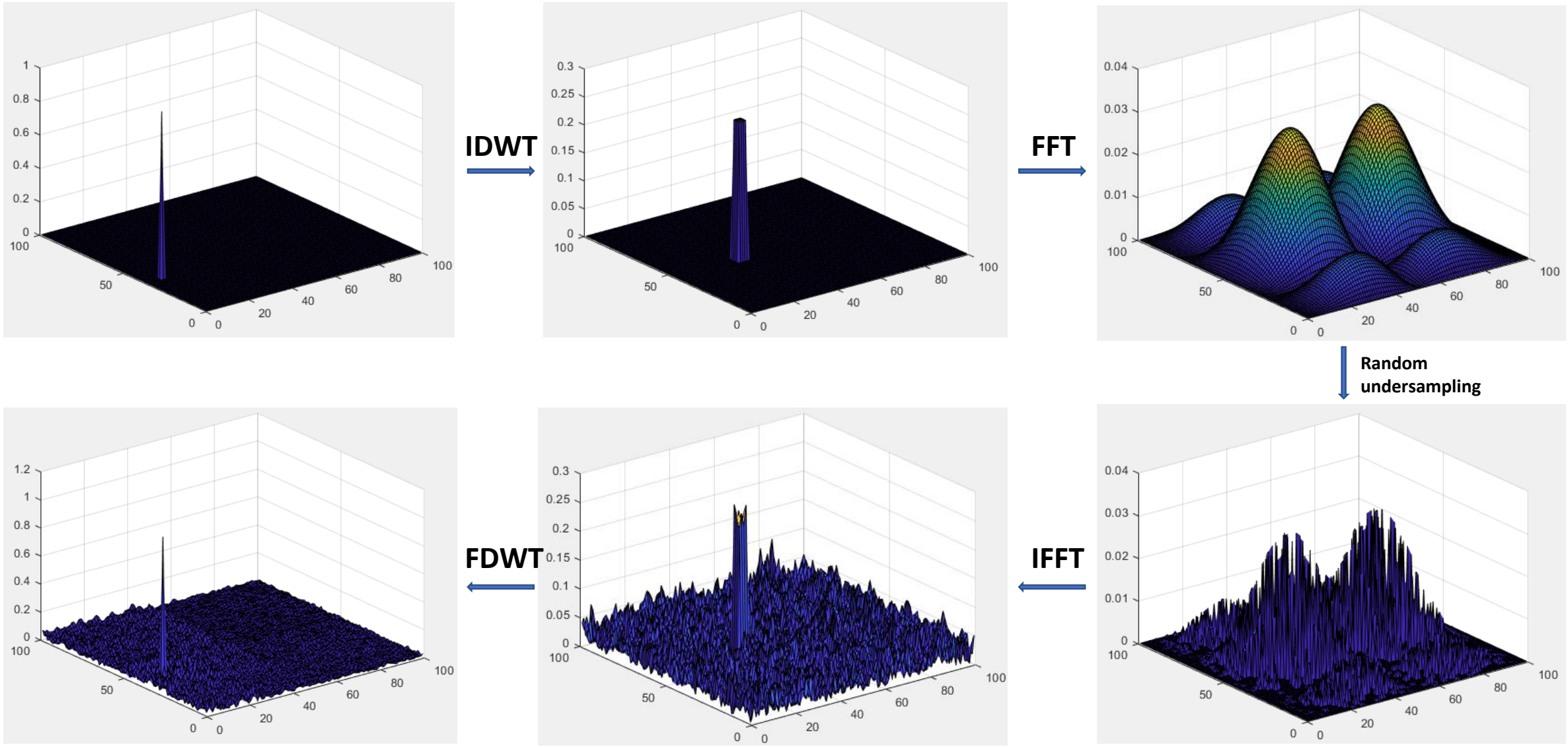
1.2. Figure 4

PSF(Point Spread Function)



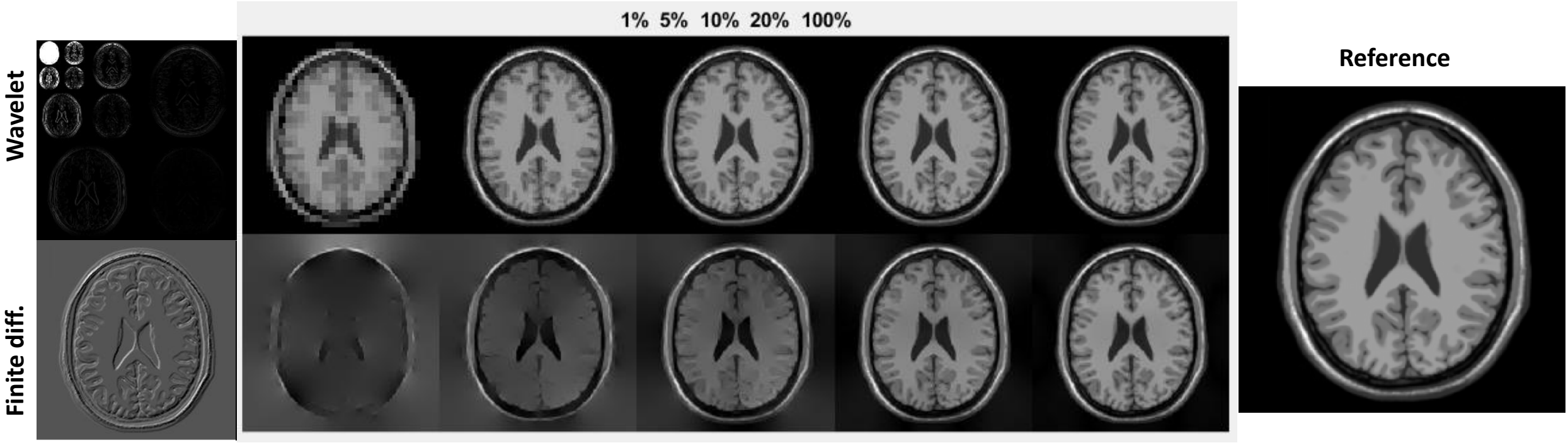
1.2. Figure 4

The wavelet TPSF(Transform Point Spread Function)

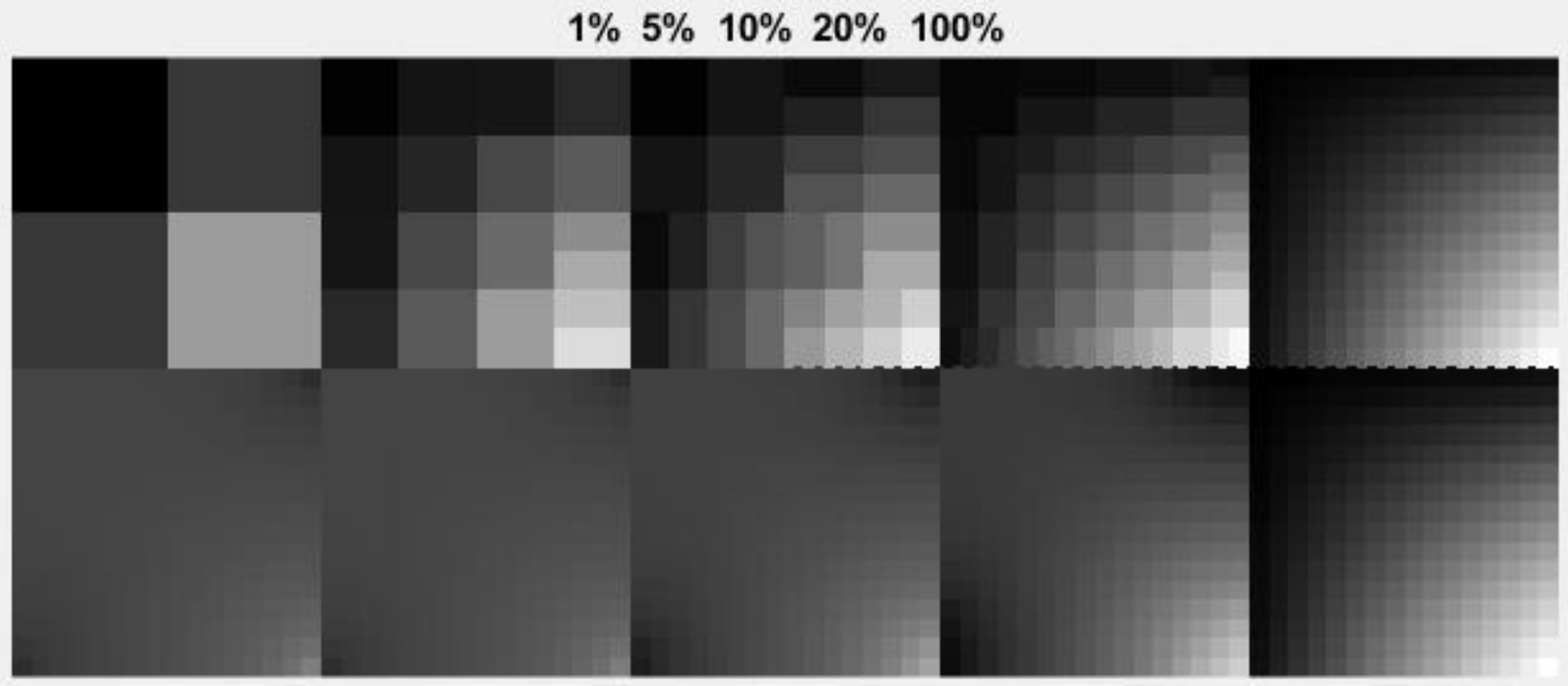


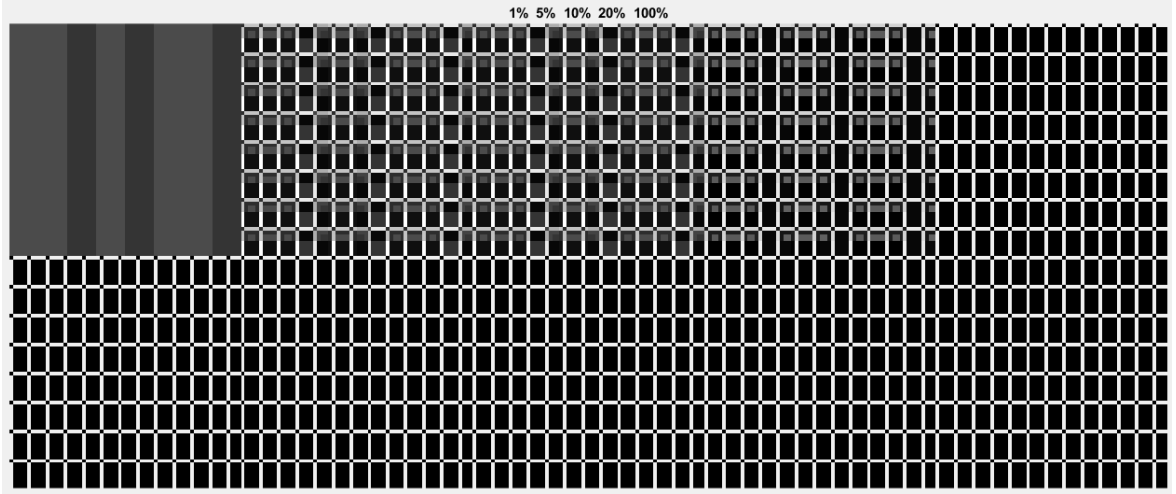
1.3. Figure 3

Transform-domain sparsity of images

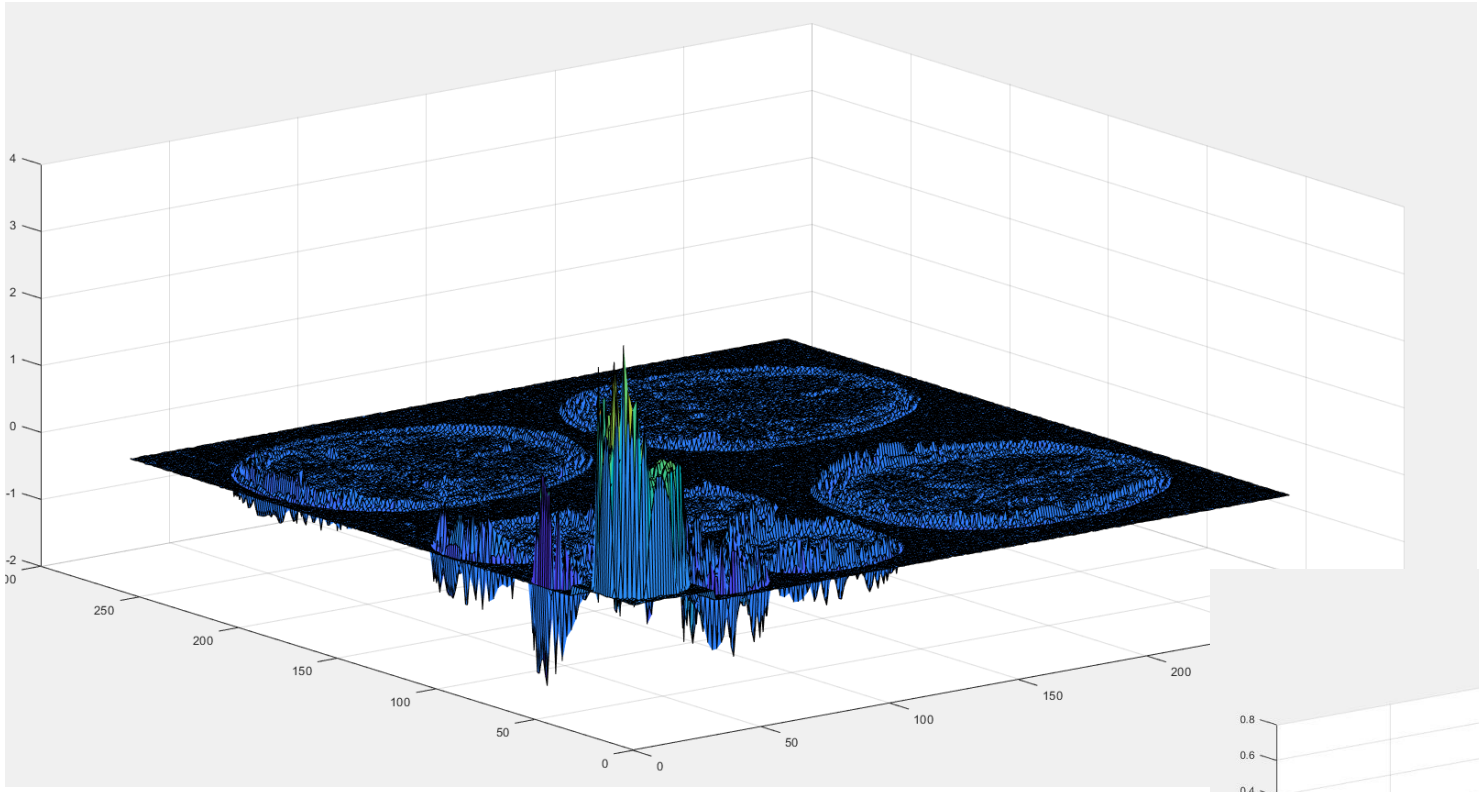


1.3. Figure 3





1.3. Figure 3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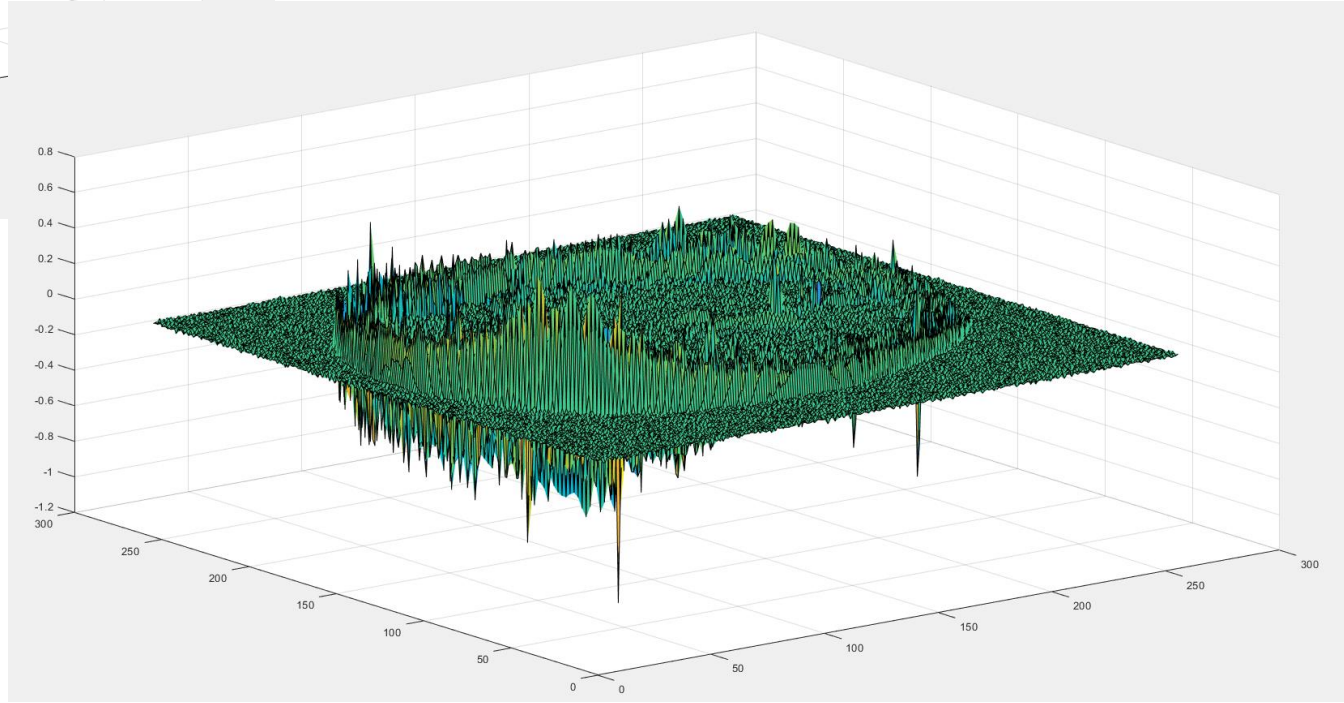
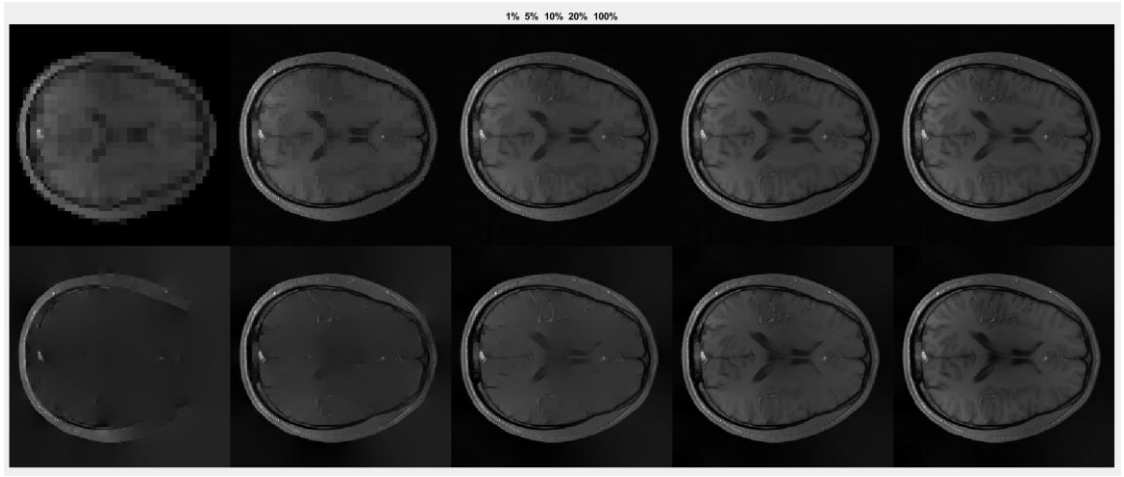
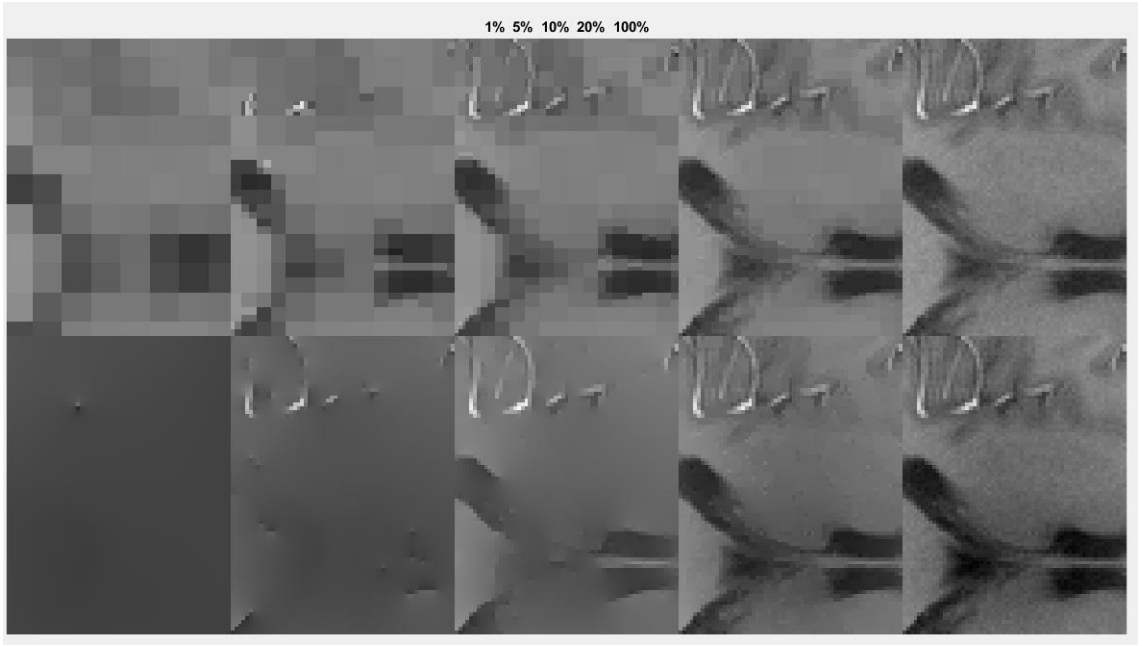
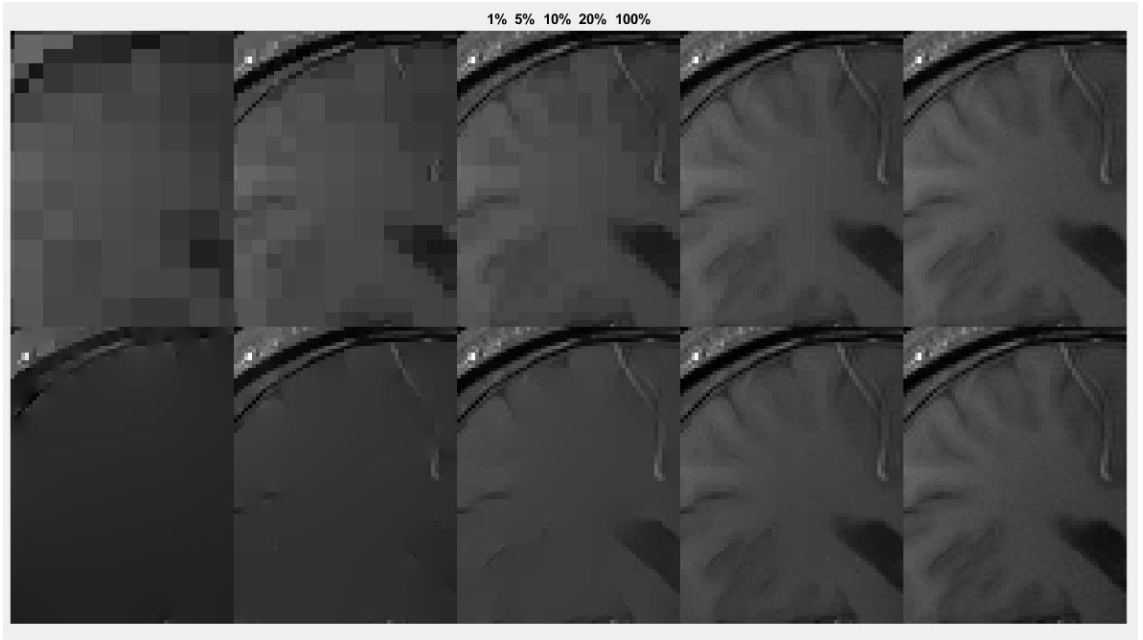
3
2
1
0
-1
-2
250
200
150
100
50
0
0
50
100
150
200


0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
300
250
200
150
100
50
0
0
50
100
150
200
250
300

1.3. Figure 3





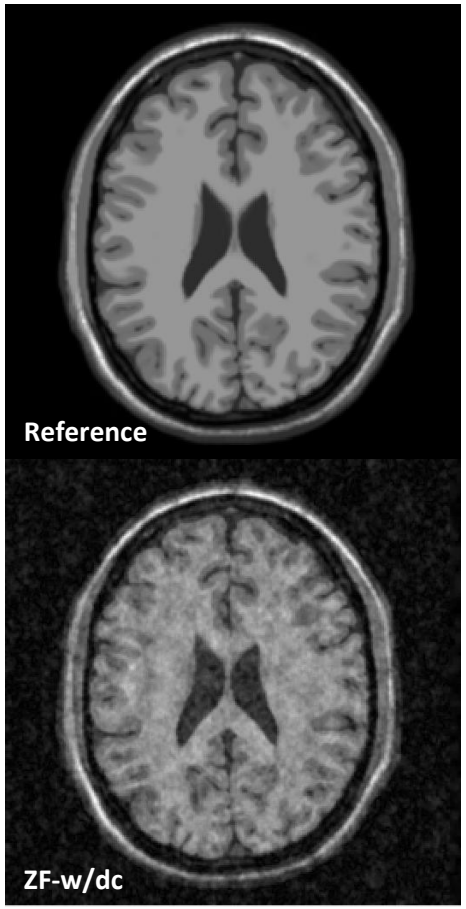


TV 가 smooth info를 잘 보전하는 것이 아니라, l1 minimization을 하면서 smooth한 entry가 날라가며 smoot에 weight를 더 주는 것이 아닌가.

+ TV 자체는 wavelet에 비해 sparsity ↓
But, l1 min으로 objective function을 세우면 smoothing property를 살릴 수 있음 => 이게 아닌가

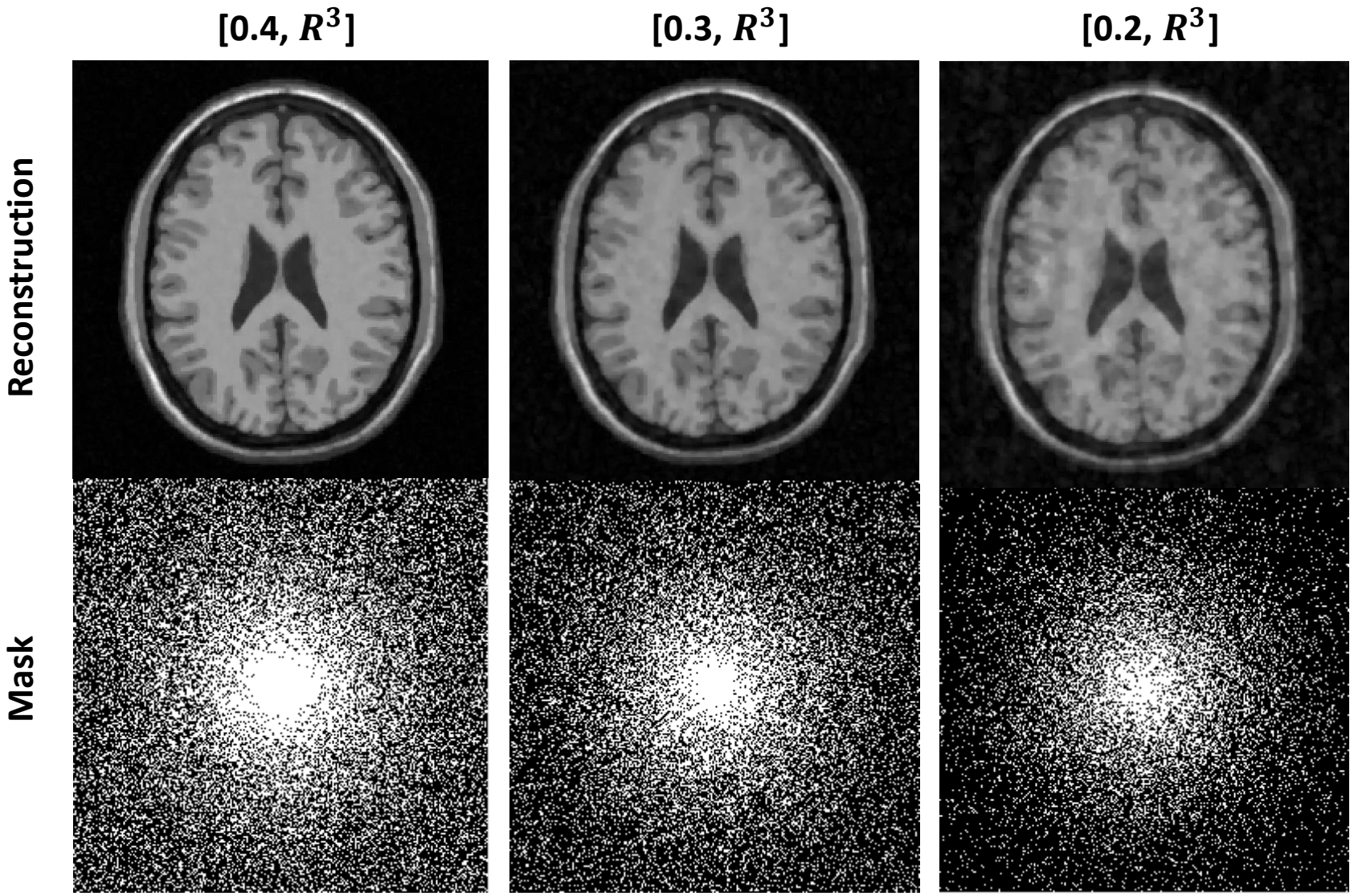
+ l1 norm으로 인해 variance 가 적은 부분들이 날라가니까 edge가 아니라 'edge position'의 info만 남아짐

1.4. Figure 6

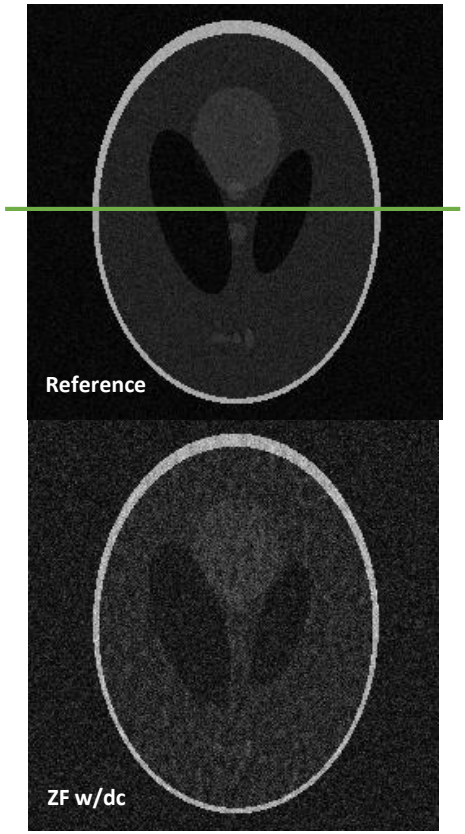


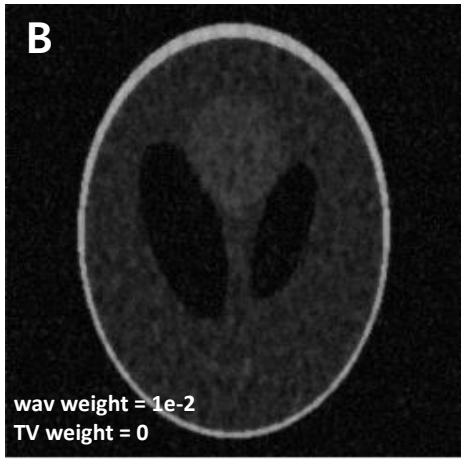
Iteration : 20
Alpha = 0.05
Beta = 0.6
Smoothing factor : 1e-6
Wavelet weight = 1e-3
TV weight = 1e-3

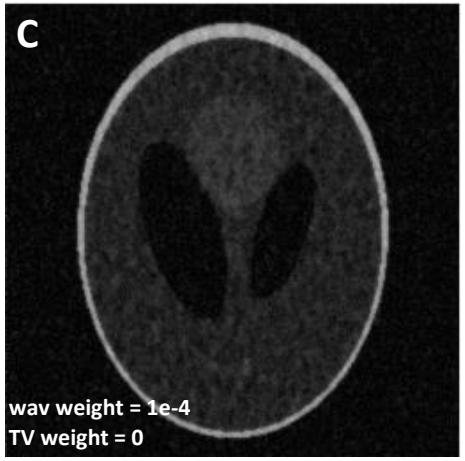
[Acquired data ratio, Density reduction factor]

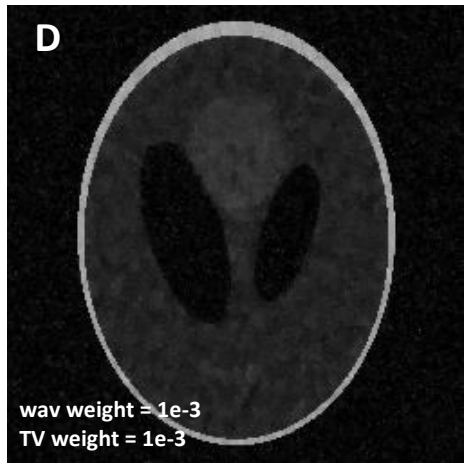


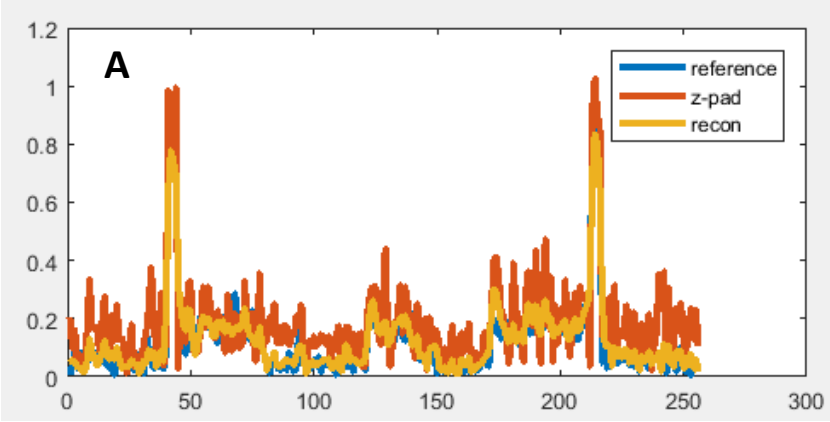
1.4. Figure 6

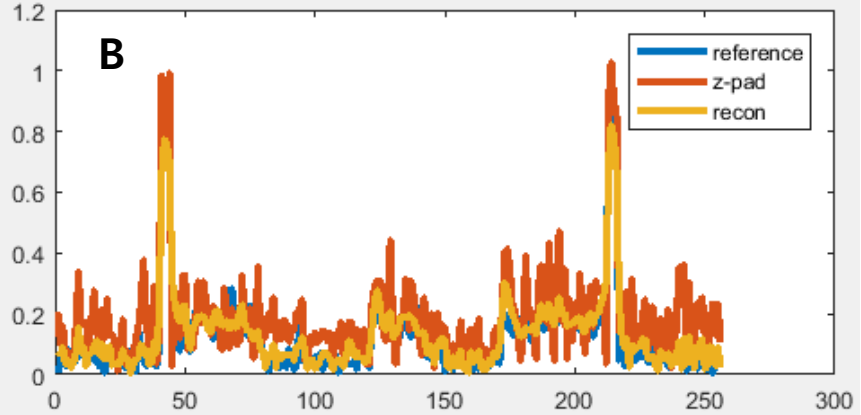


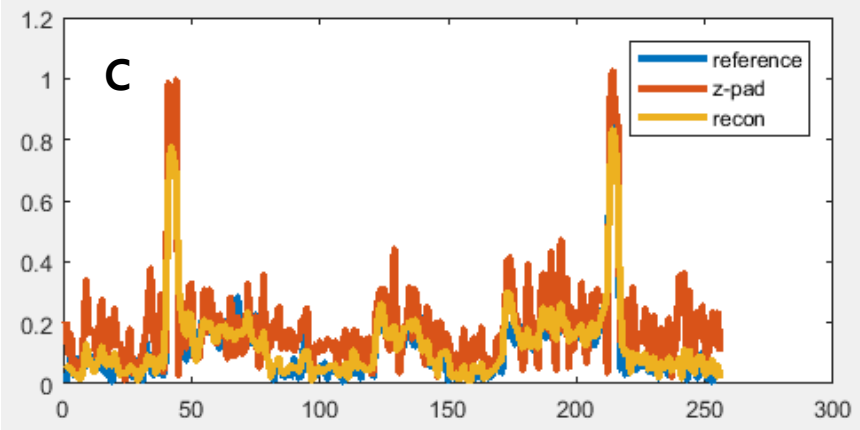


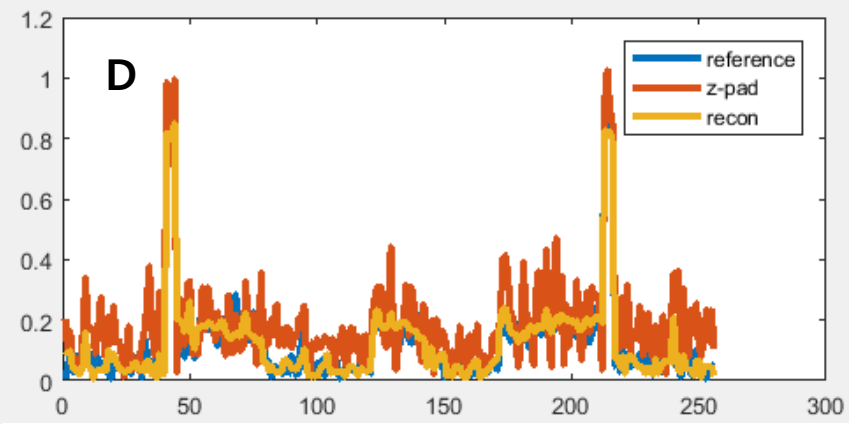


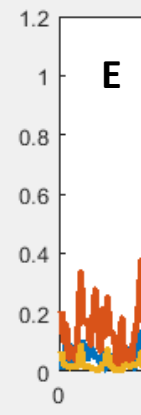






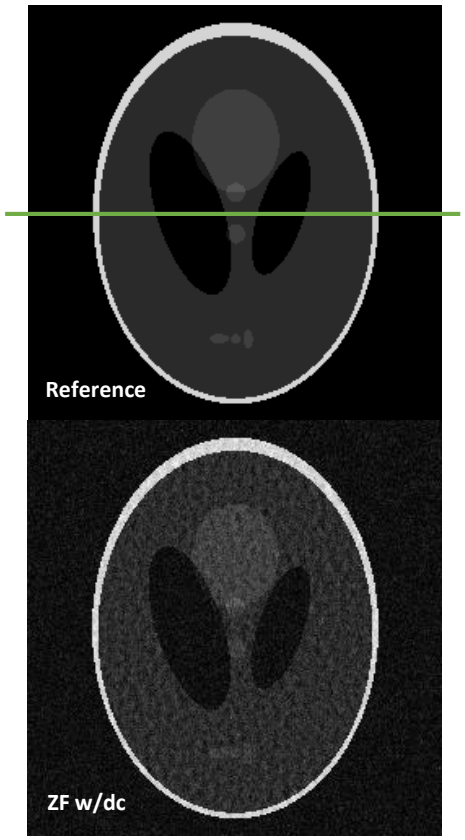


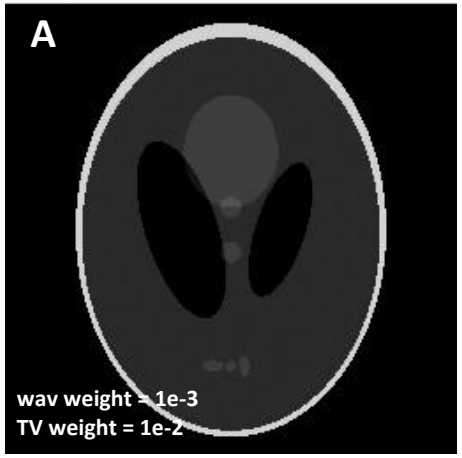


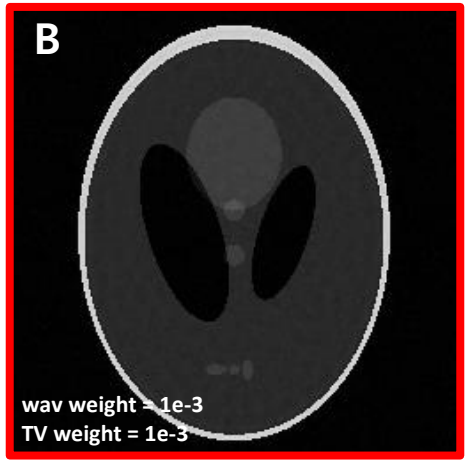


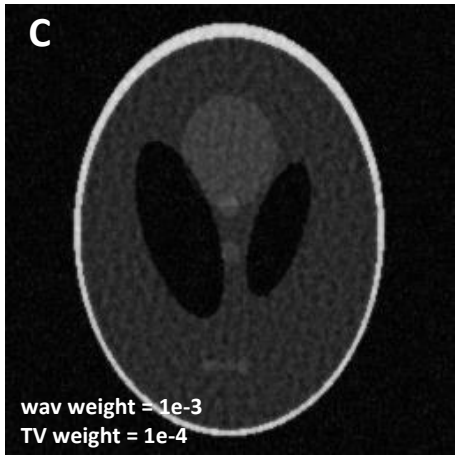
Iteration : 50
Alpha = 0.05
Beta = 0.6
Smoothing factor : 1e-6
Noise = 0.05
mask $\propto R^3, 0.3$

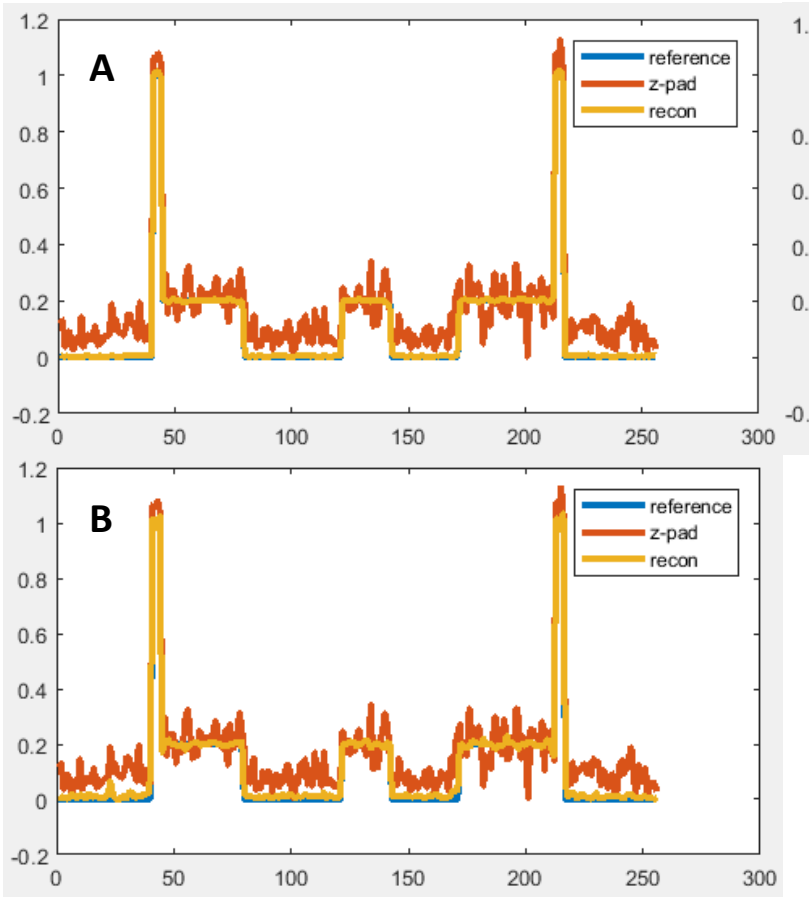
1.4. Figure 6

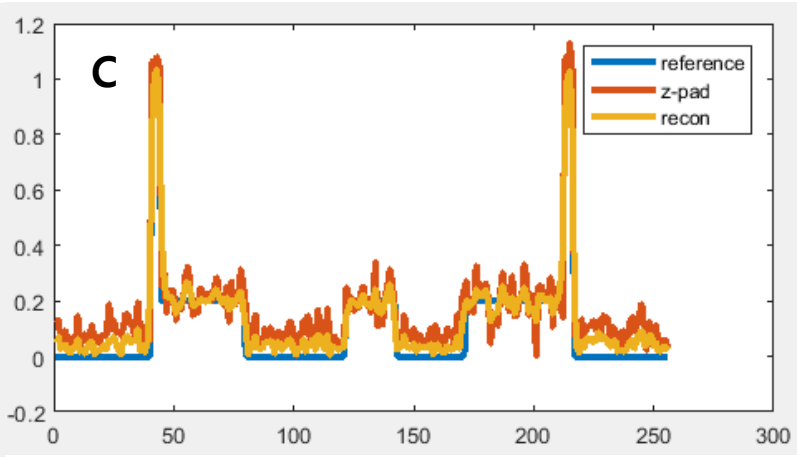






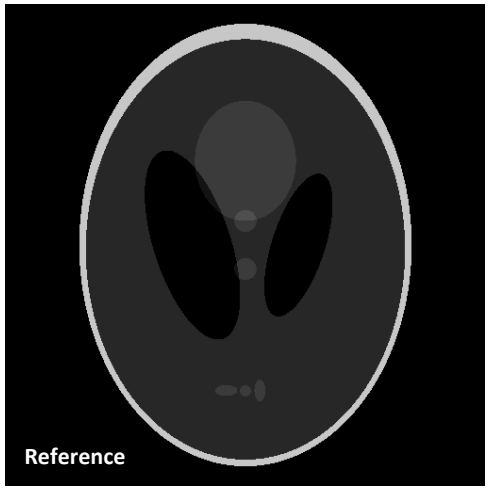






Iteration : 20
Alpha = 0.05
Beta = 0.6
Smoothing factor : 1e-6
mask $\propto R^3, 0.3$

1.4. Figure 6

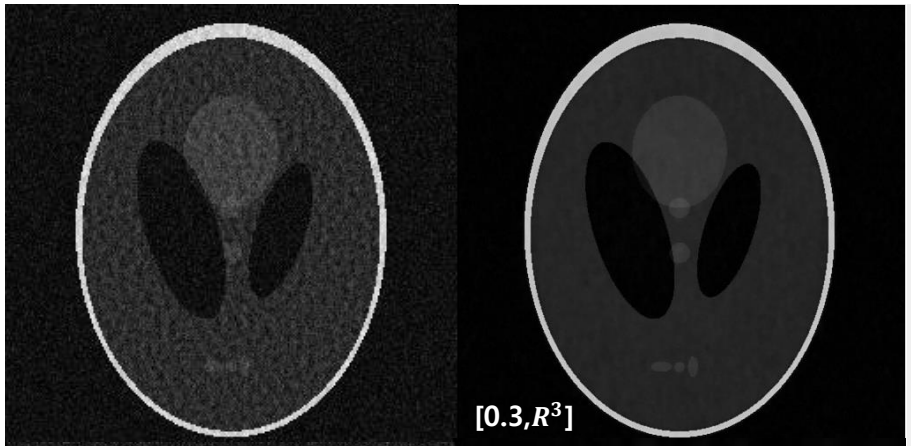


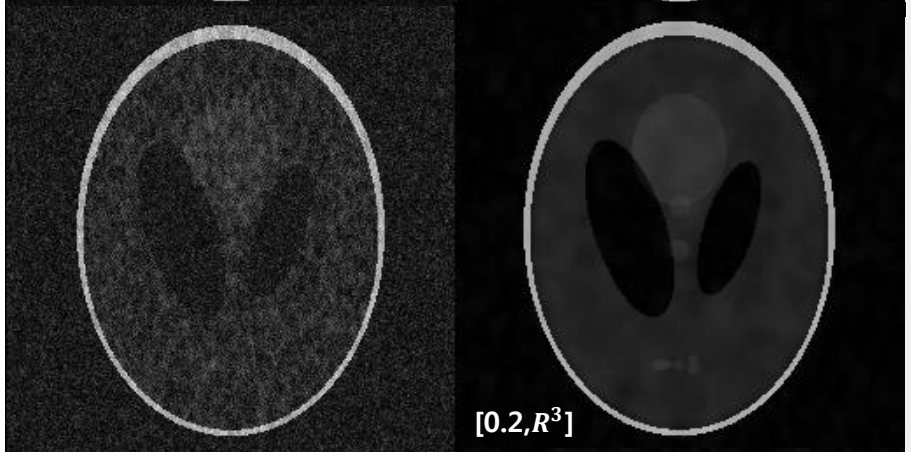
Iteration : 20
Alpha = 0.05
Beta = 0.6
Smoothing factor : 1e-6

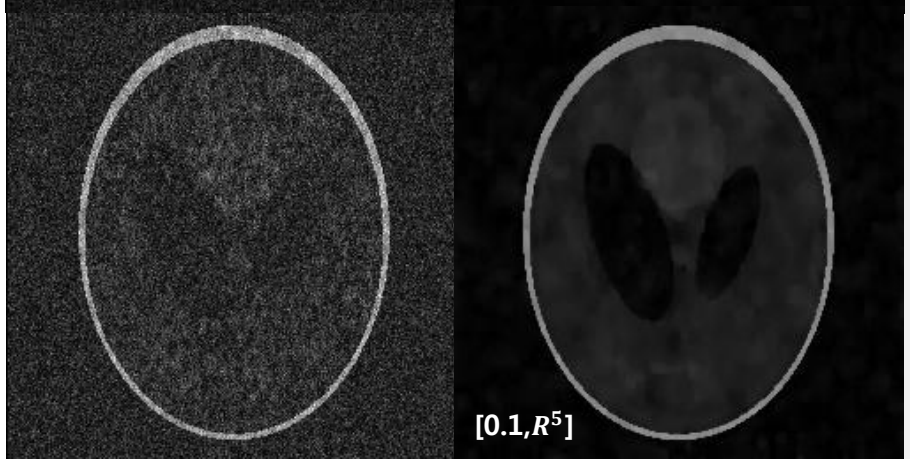
Wavelet weight = 1e-3
TV weight = 1e-2

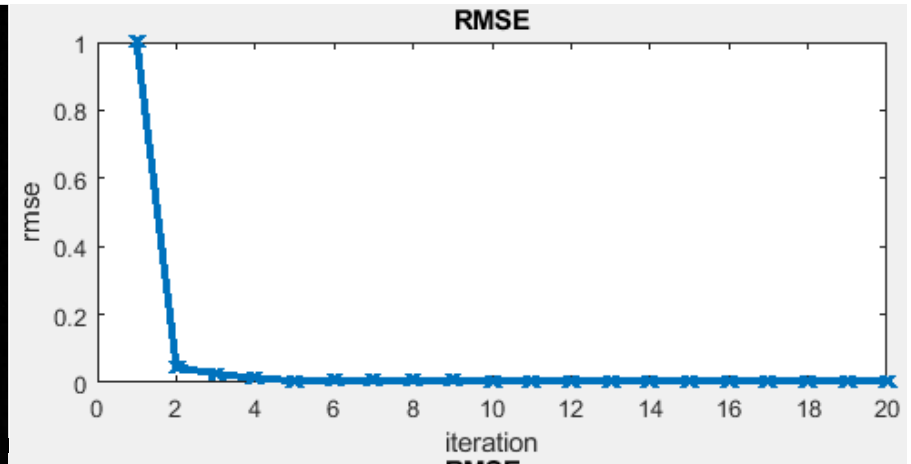
ZF-w/dc

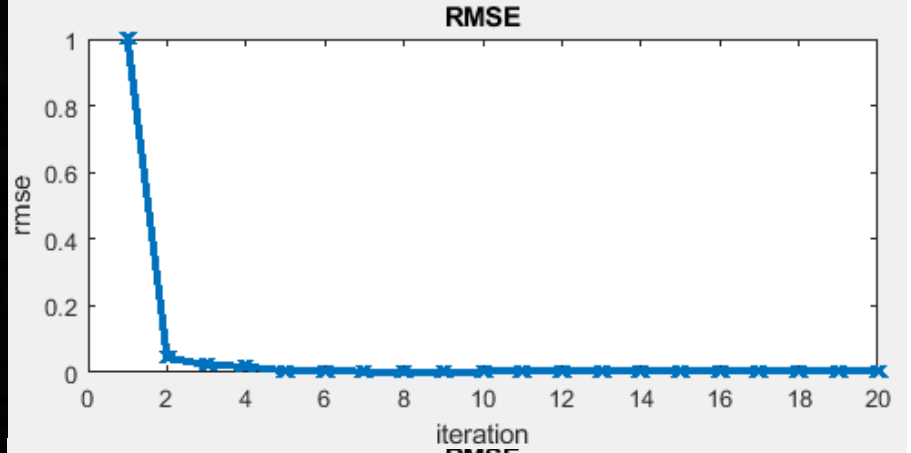
[Acquired data ratio, Density reduction factor]

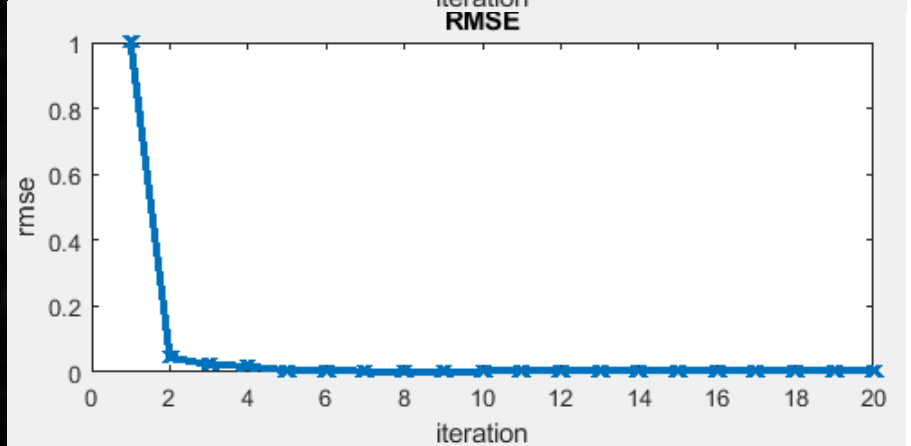




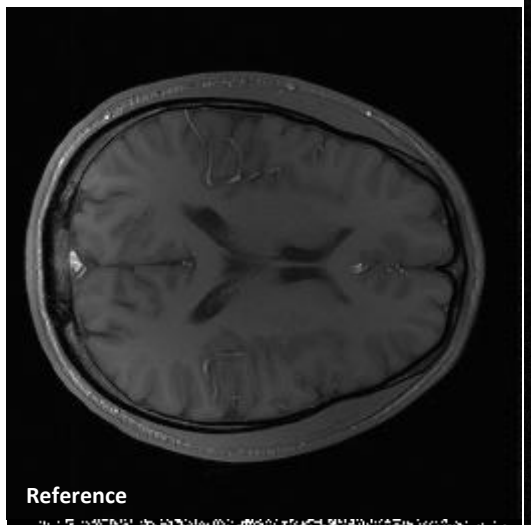


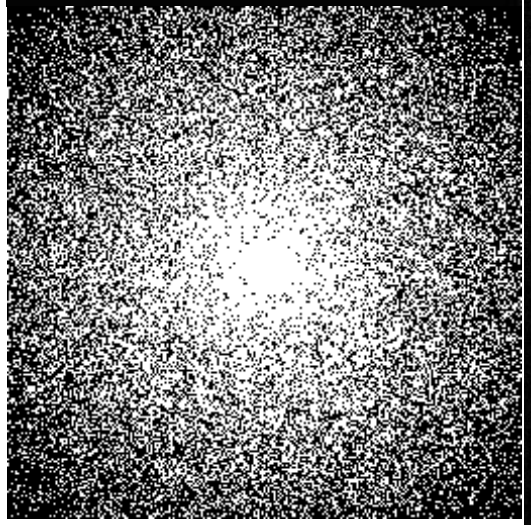




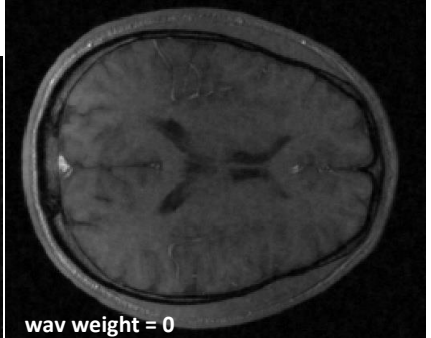


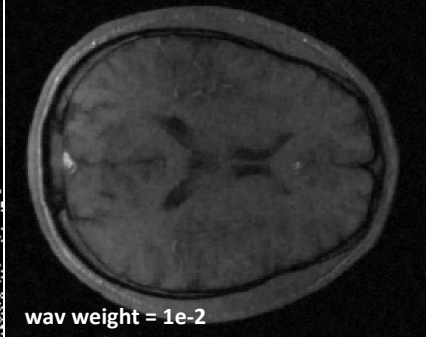
1.4. Figure 6

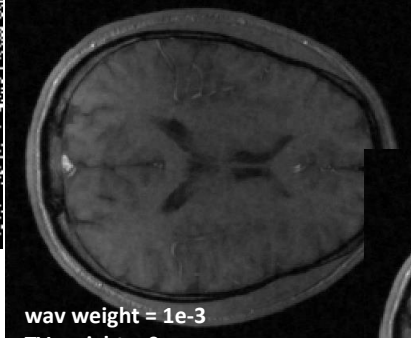


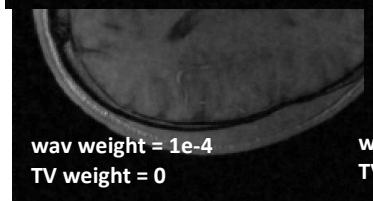


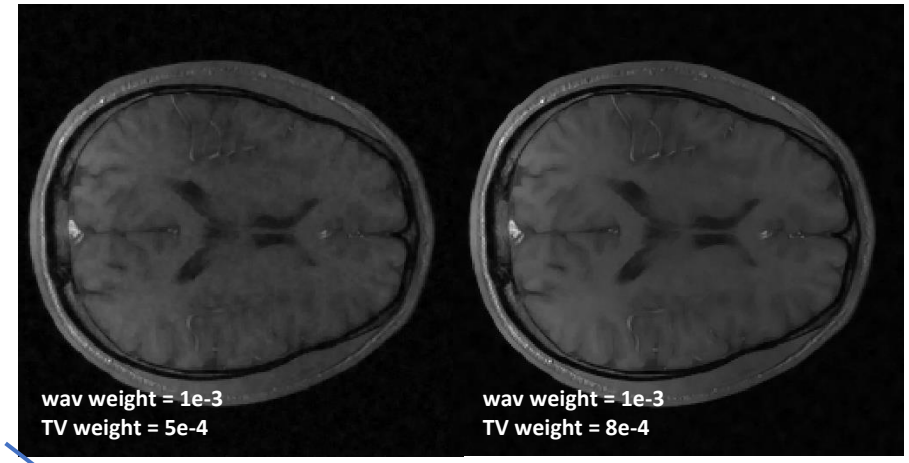
Iteration : 80
Alpha = 0.05
Beta = 0.6
Smoothing factor : 1e-6
mask $\propto R^1, 0.5$

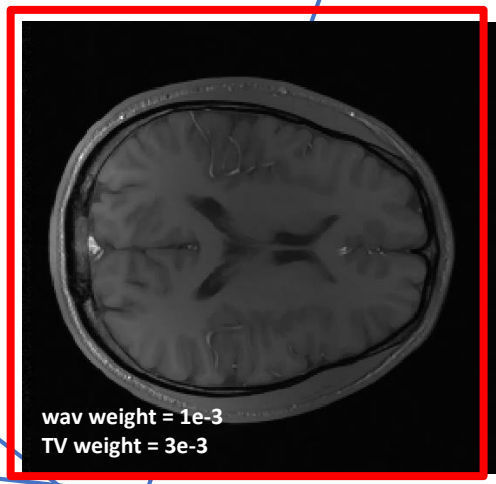


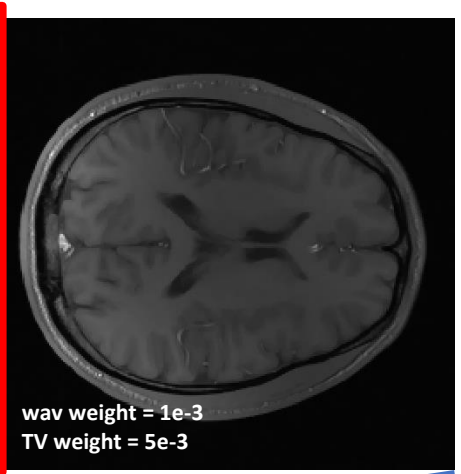


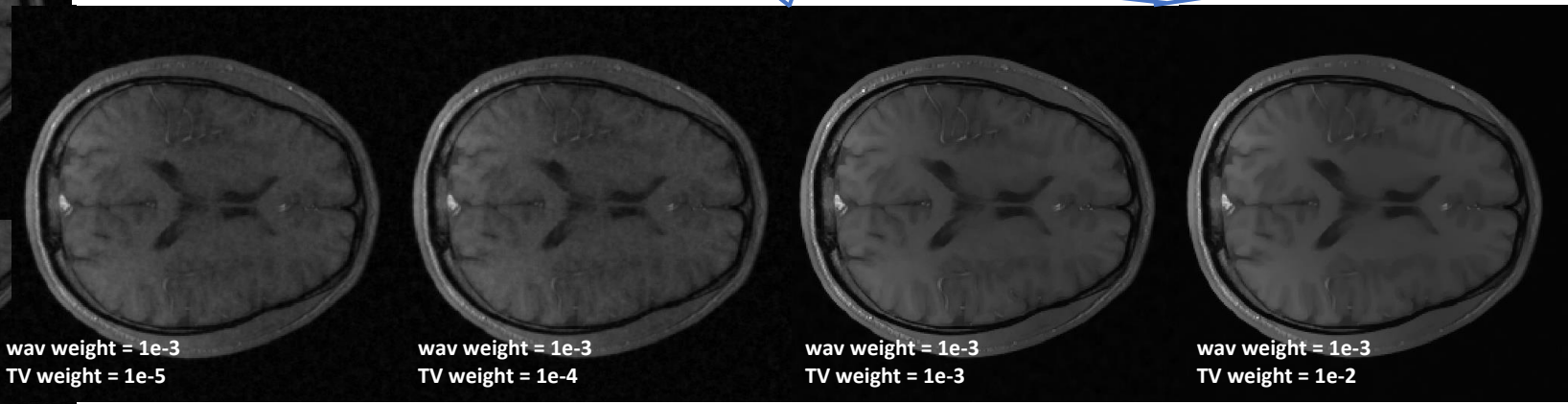




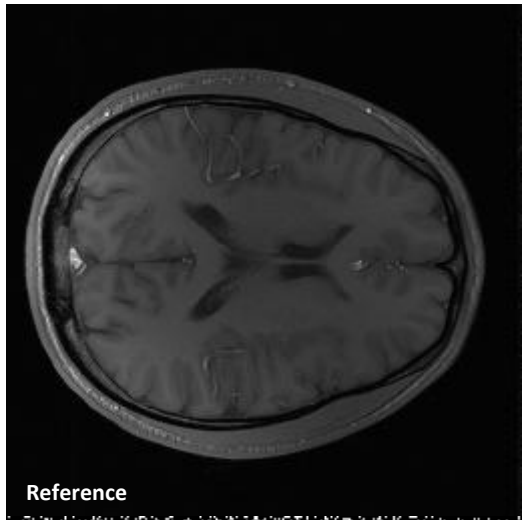


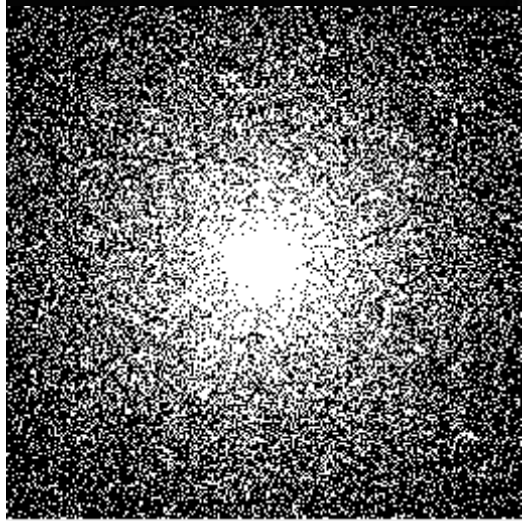


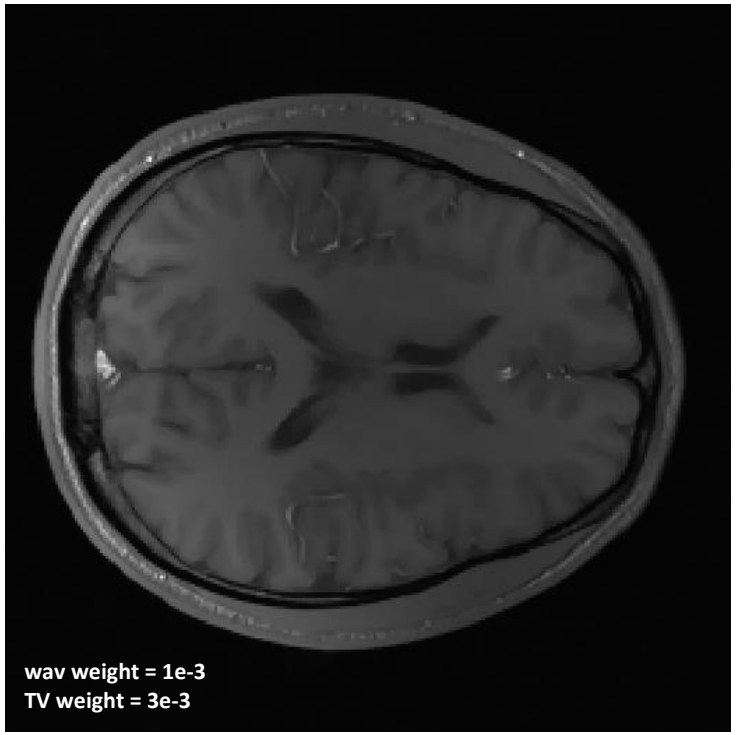




1.4. Figure 6

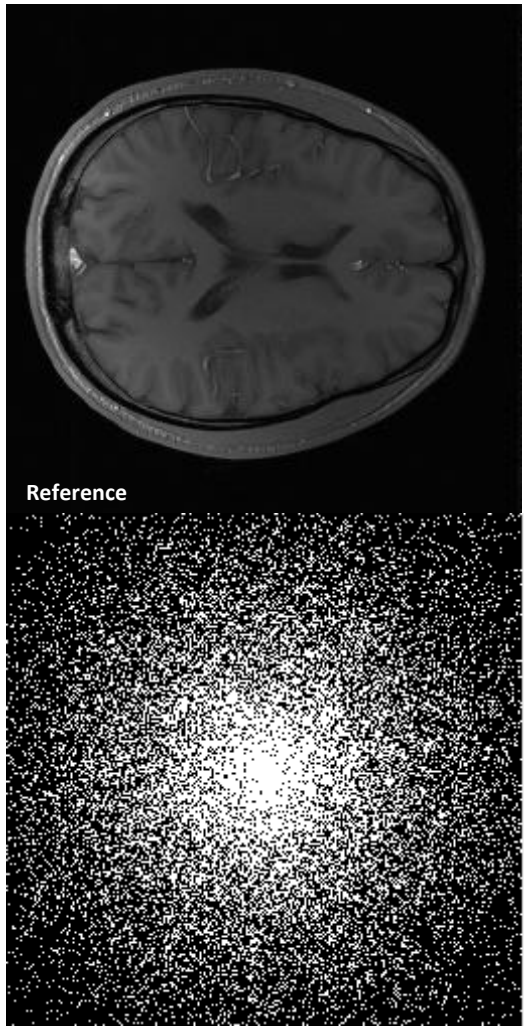


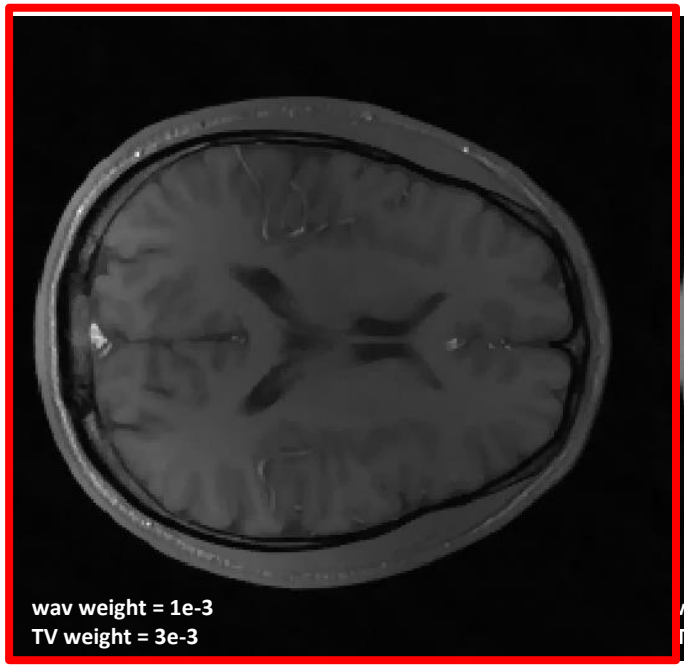


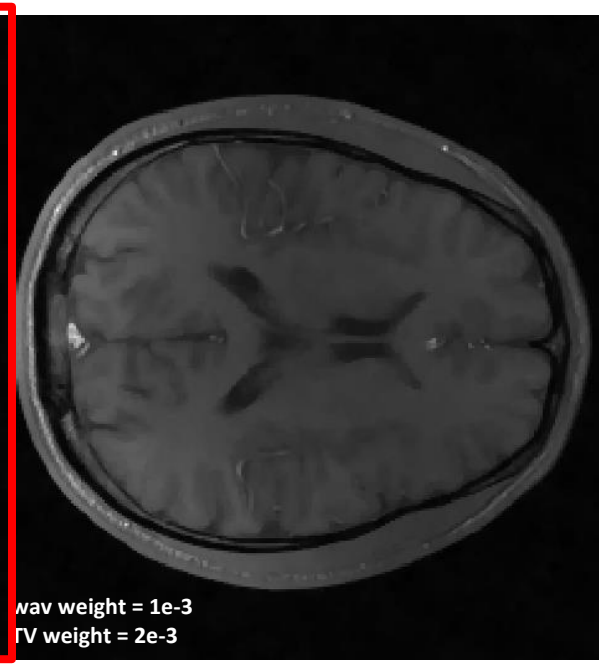


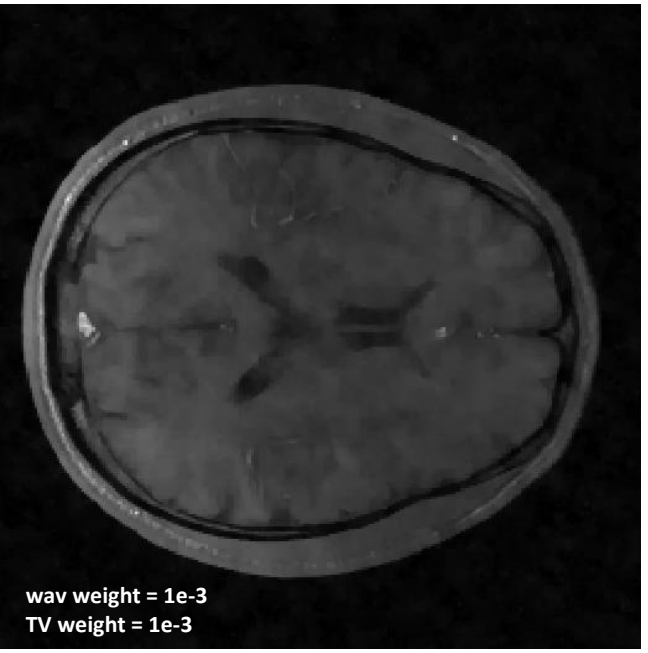
Iteration : 80
Alpha = 0.05
Beta = 0.6
Smoothing factor : 1e-6
mask $\propto R^2, 0.4$

1.4. Figure 6



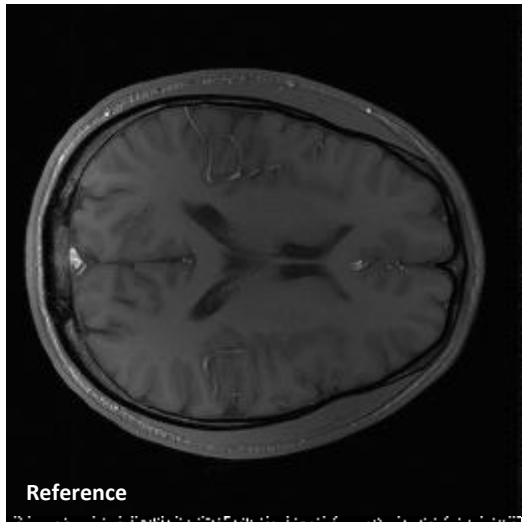


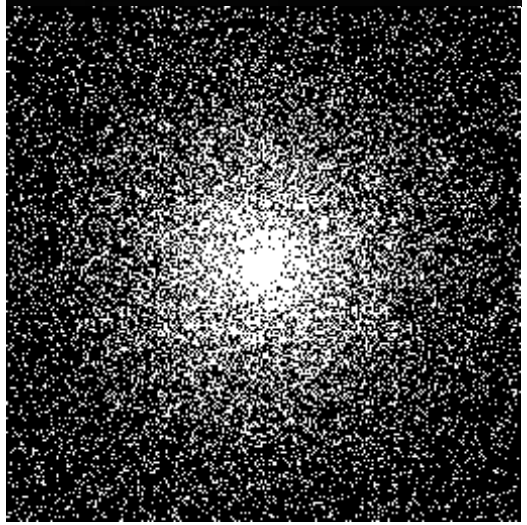




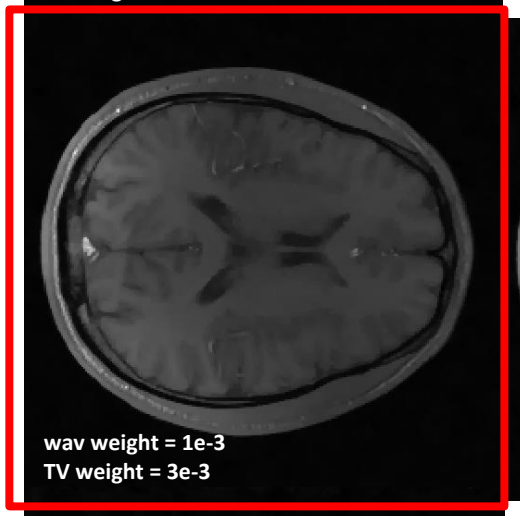
Iteration : 80
Alpha = 0.05
Beta = 0.6
Smoothing factor : 1e-6
mask $\propto R^2, 0.3$

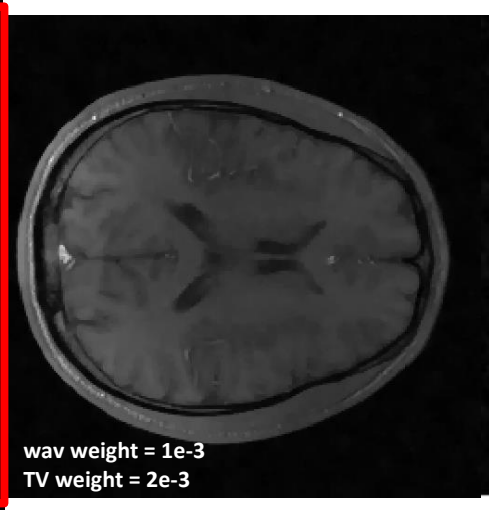
1.4. Figure 6

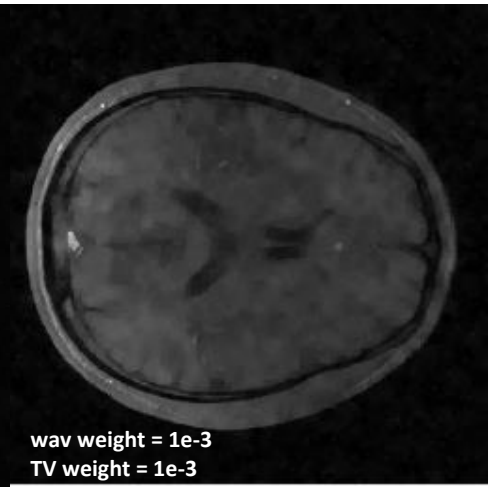




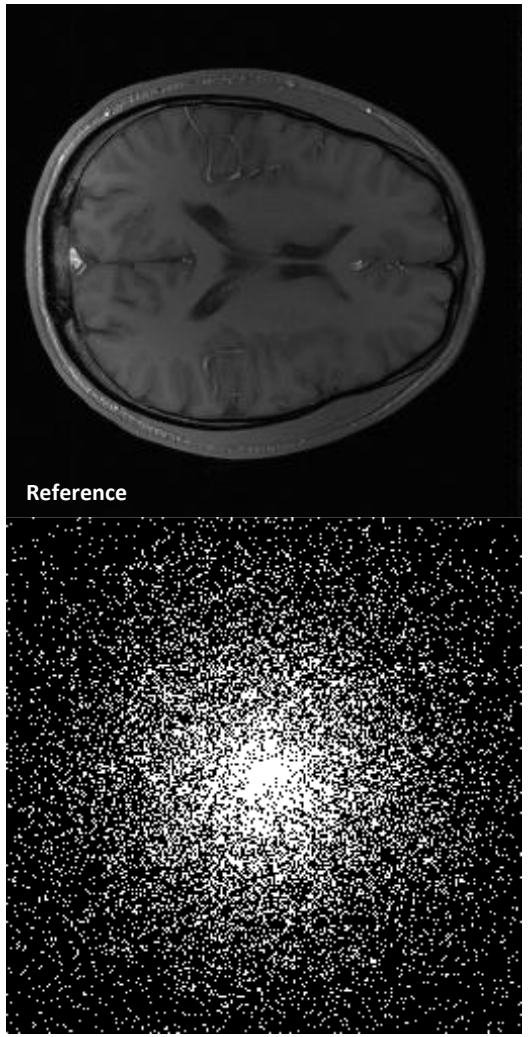
Iteration : 80
Alpha = 0.05
Beta = 0.6
Smoothing factor : 1e-6
mask $\propto R^3, 0.25$

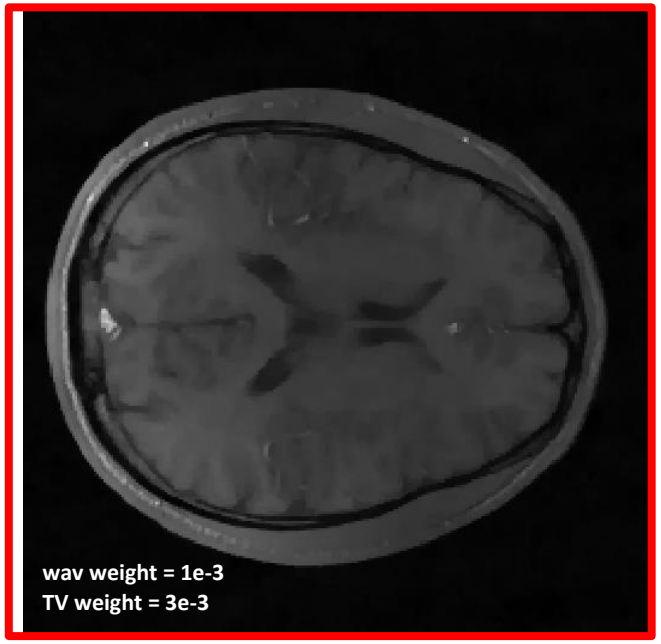


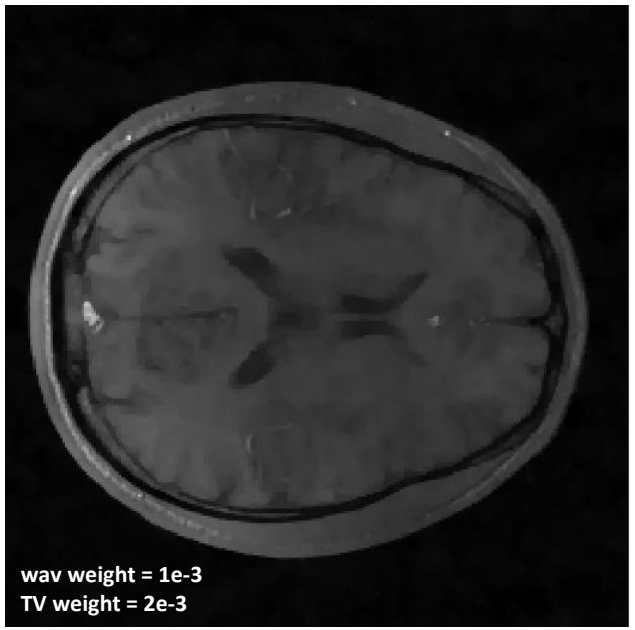


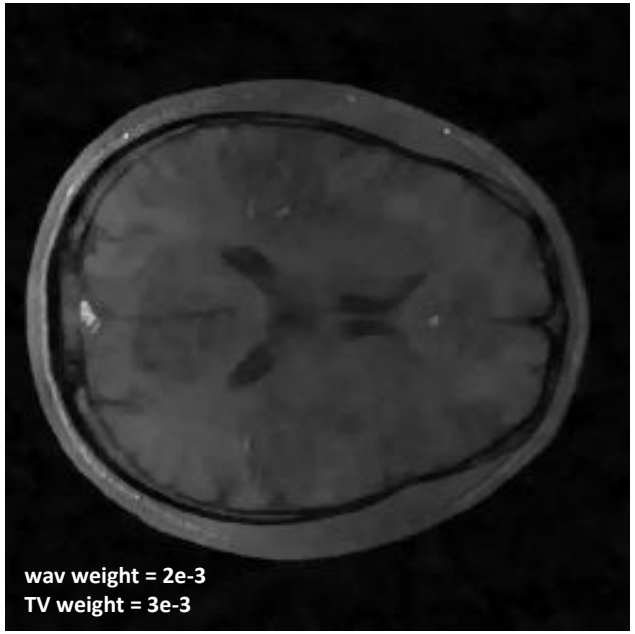


1.4. Figure 6



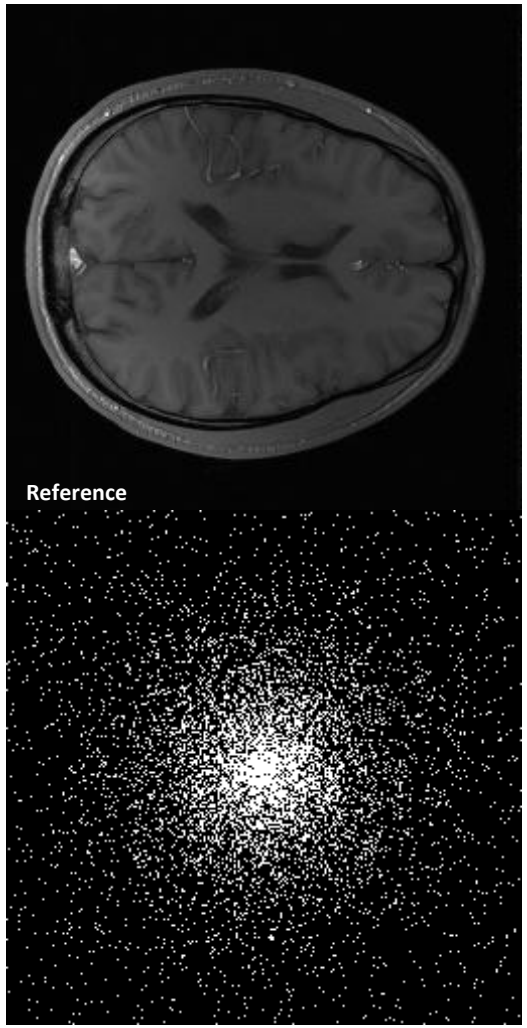


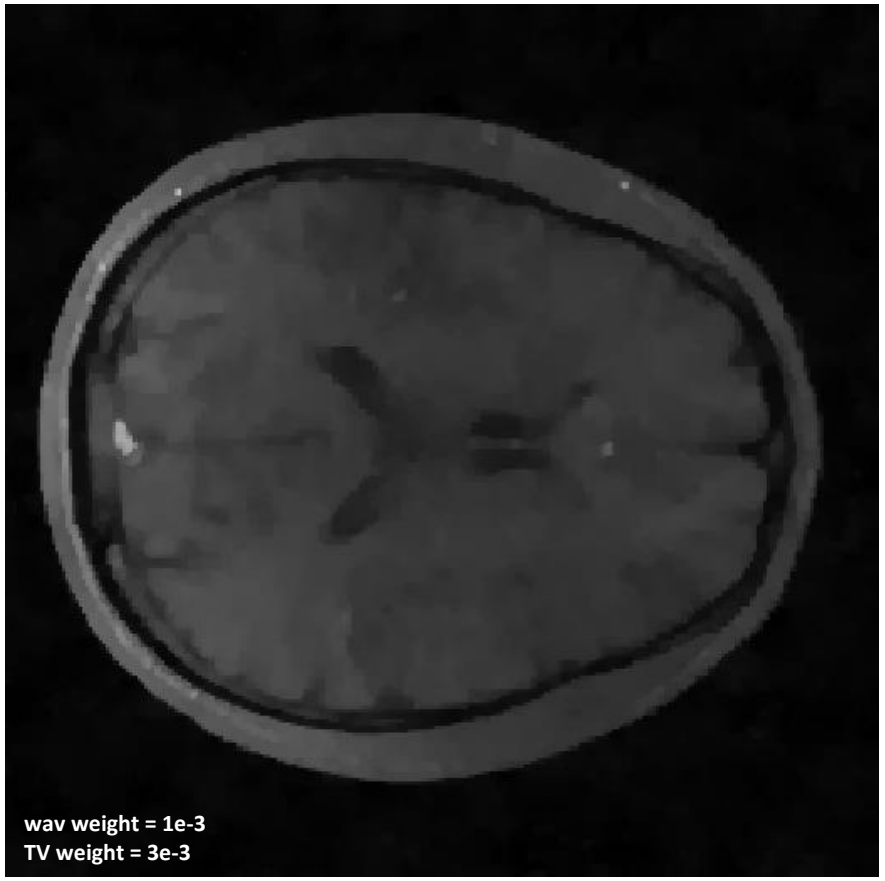




Iteration : 80
Alpha = 0.05
Beta = 0.6
Smoothing factor : 1e-6
mask $\propto R^3, 0.2$

1.4. Figure 6





Iteration : 80
Alpha = 0.05
Beta = 0.6
Smoothing factor : 1e-6
mask $\propto R^5, 0.1$

2.
CS SENSE

Sparse MRI :

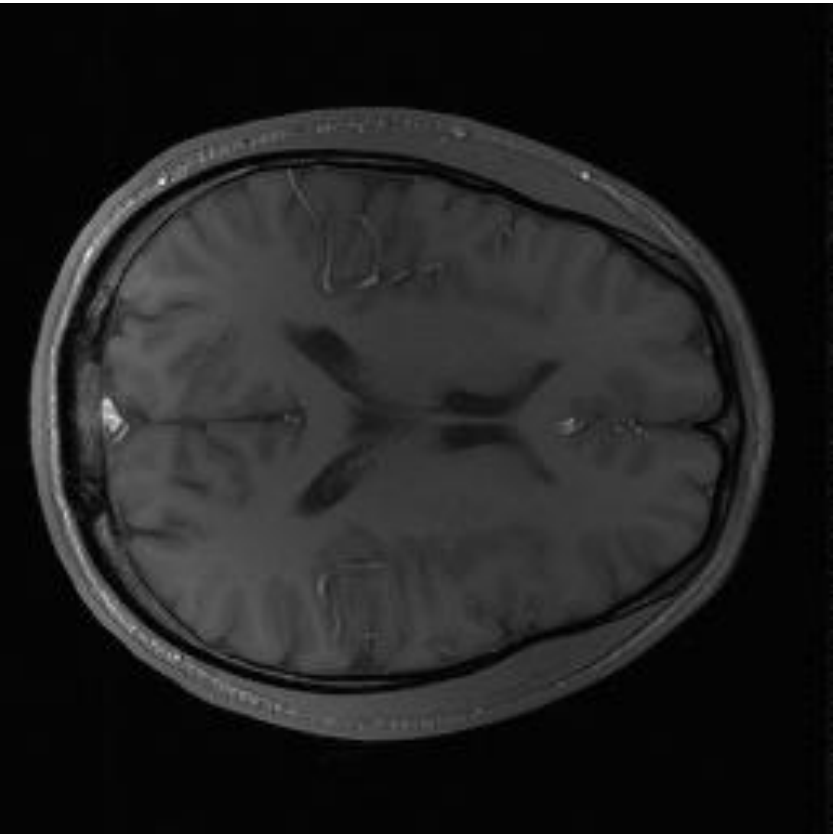
$$\begin{aligned} minimize \quad & \|\Psi m\|_1 \\ s.t. \quad & \|\mathcal{F}_u m - y\|_2 < \epsilon \end{aligned}$$

CS SENSE :

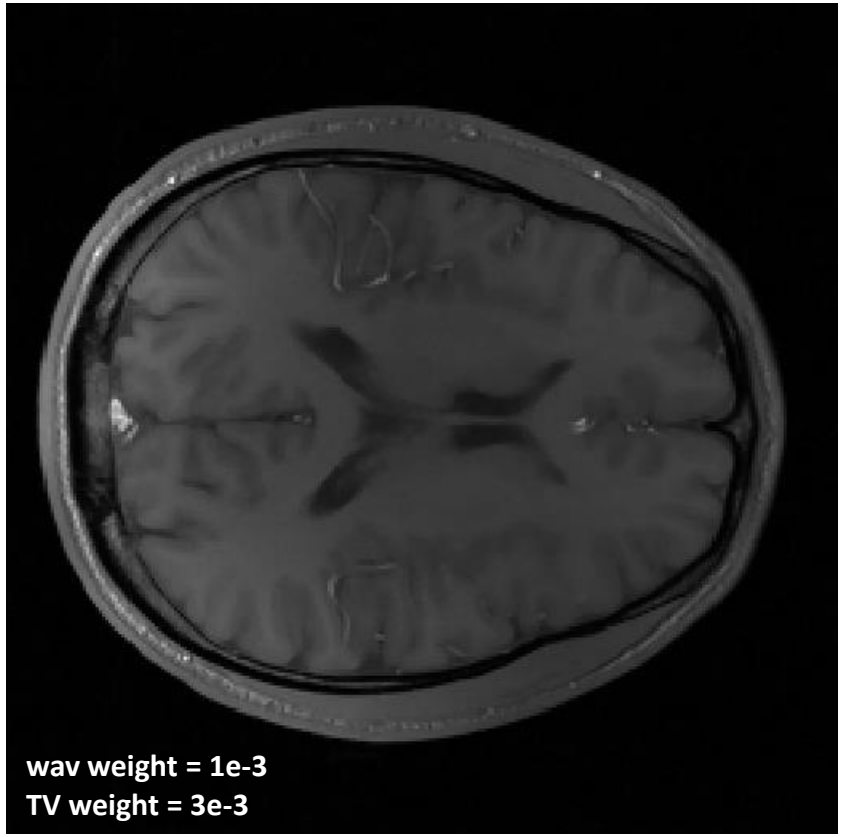
$$\min_{\mathbf{f}} (\|\boldsymbol{\Psi}\mathbf{f}\|_1 + \alpha\|\mathbf{f}\|_{\mathrm{TV}}) \text{ s.t.} \|\mathbf{E}\mathbf{f} - \mathbf{d}\|_2 \leq \varepsilon$$

1.4. Figure 6

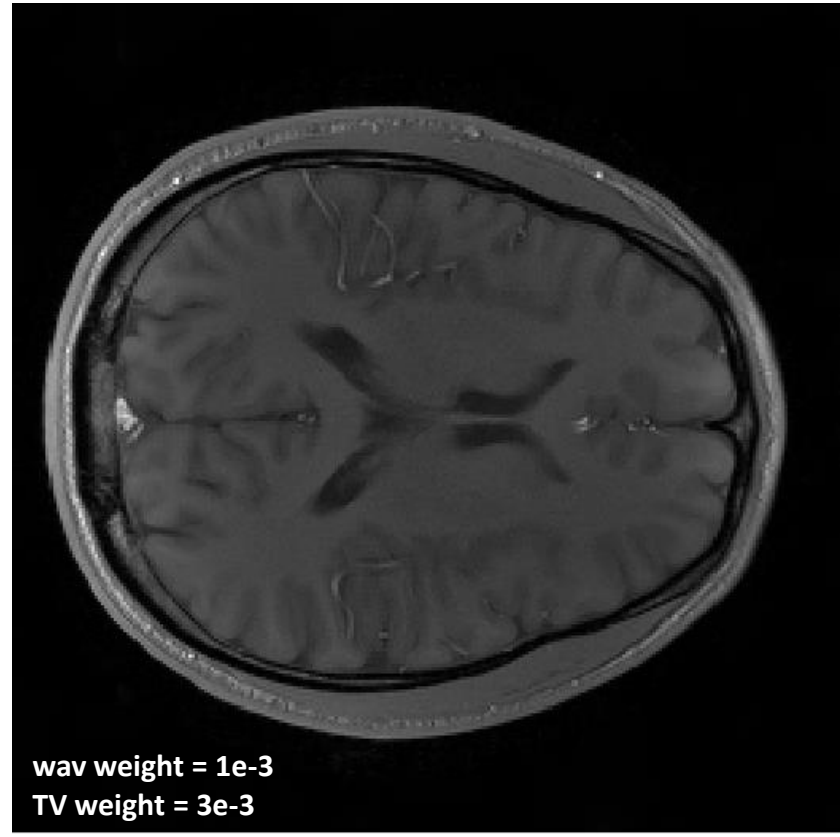
Ground Truth



Sparse SENSE



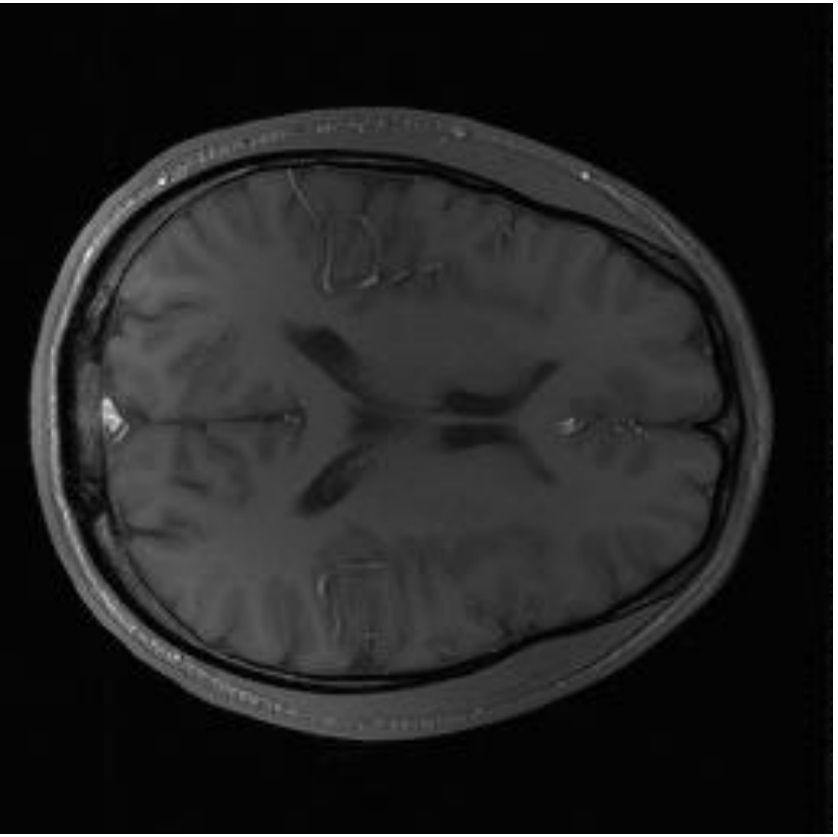
CS SENSE



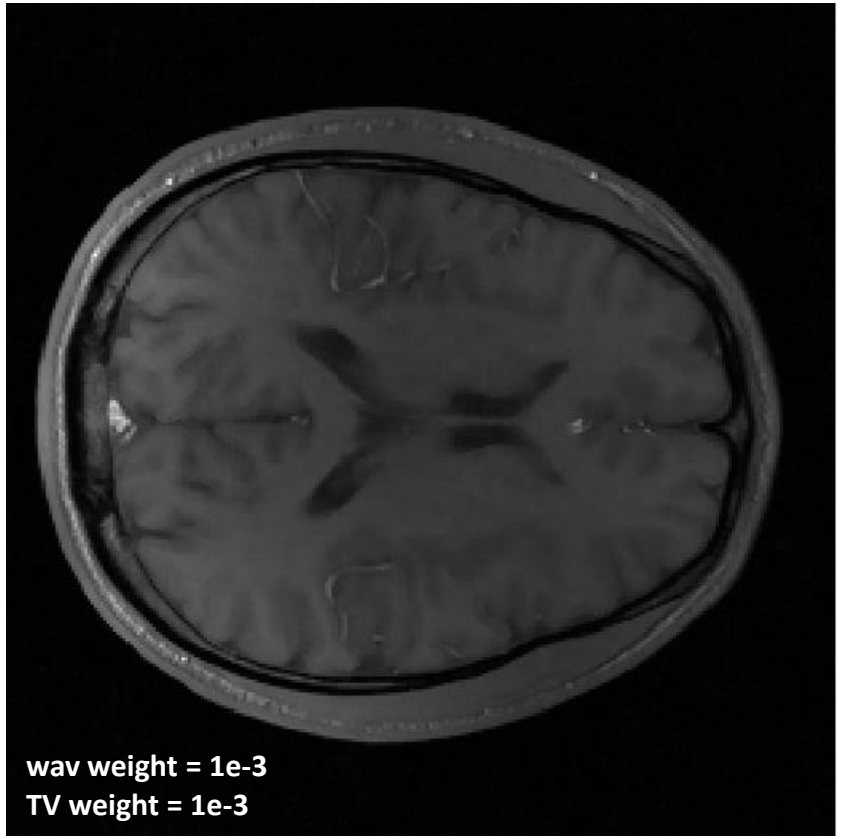
Iteration : 80
Alpha = 0.05
Beta = 0.6
Smoothing factor : 1e-6
mask $\propto R^1, 0.5$

1.4. Figure 6

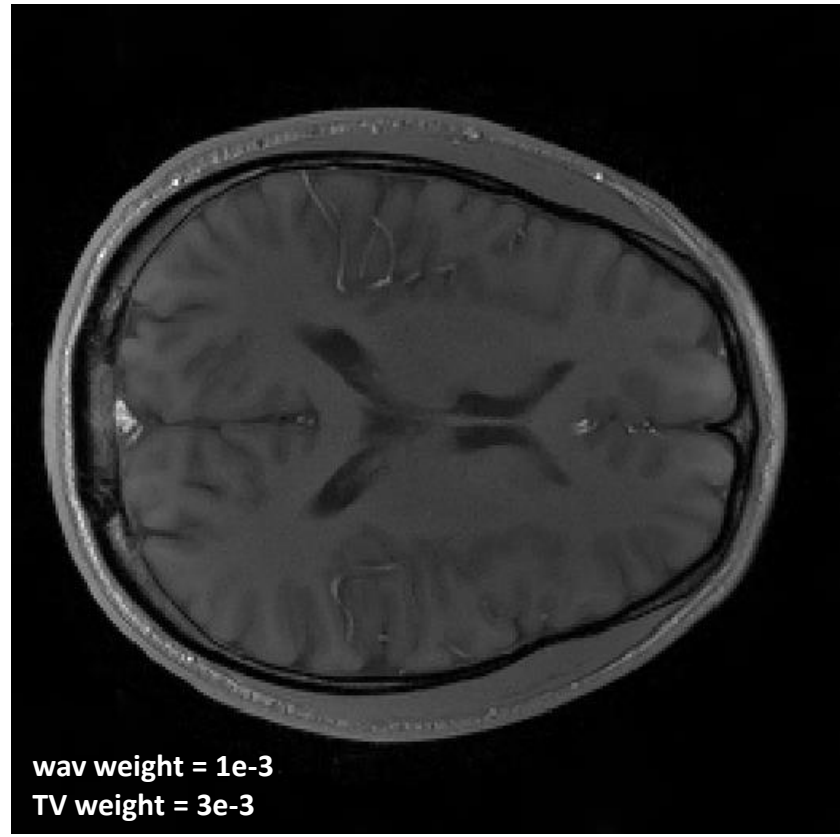
Ground Truth



Sparse SENSE



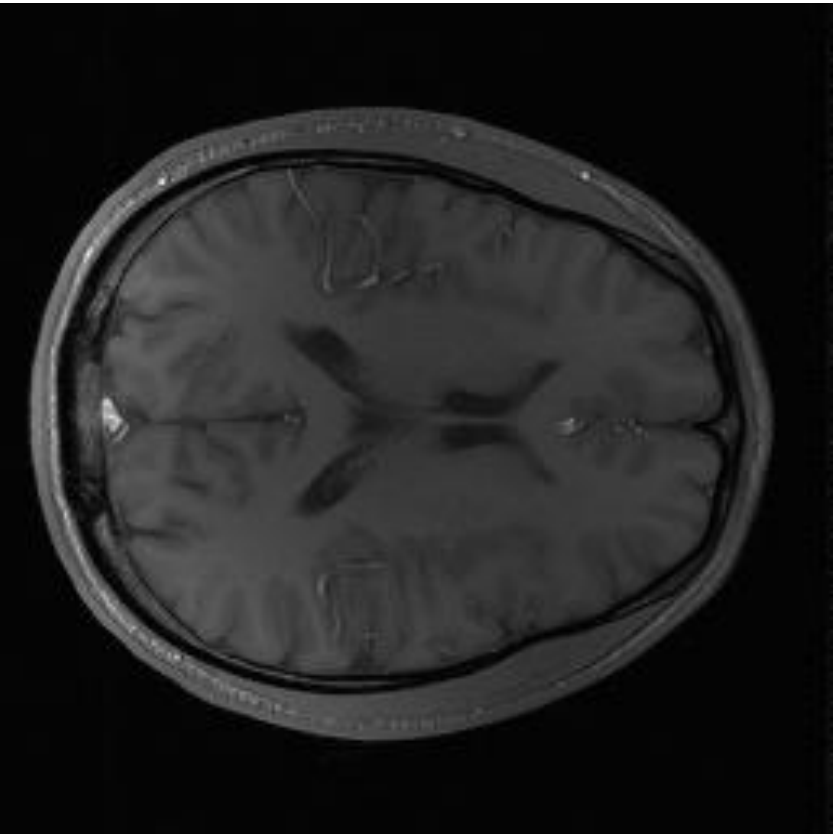
CS SENSE



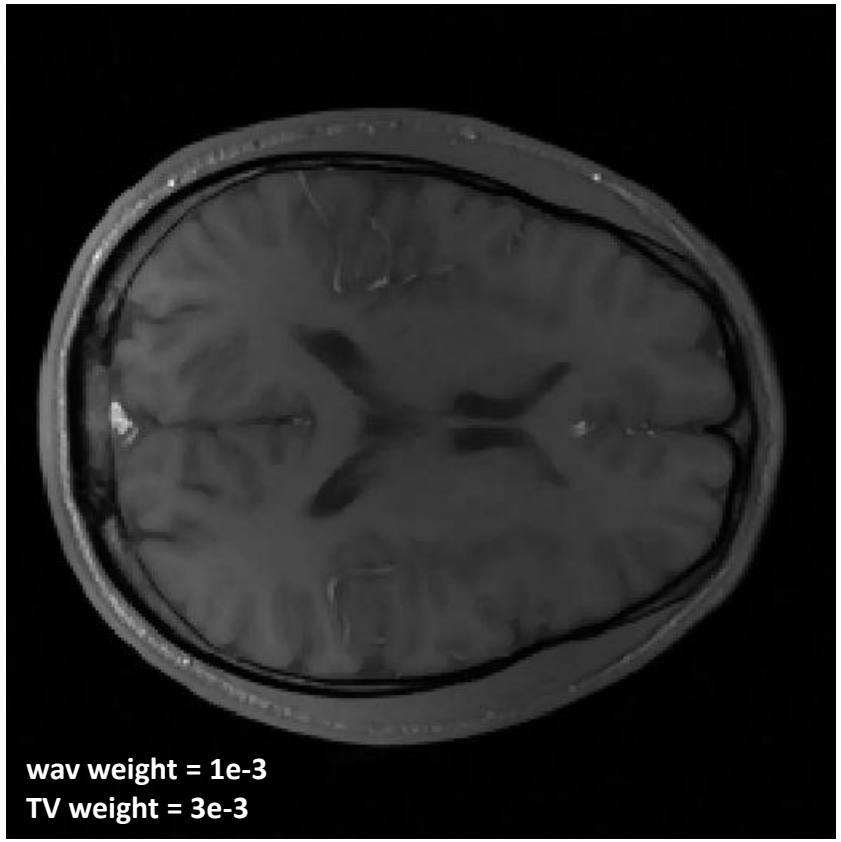
Iteration : 80
Alpha = 0.05
Beta = 0.6
Smoothing factor : 1e-6
mask $\propto R^2, 0.4$

1.4. Figure 6

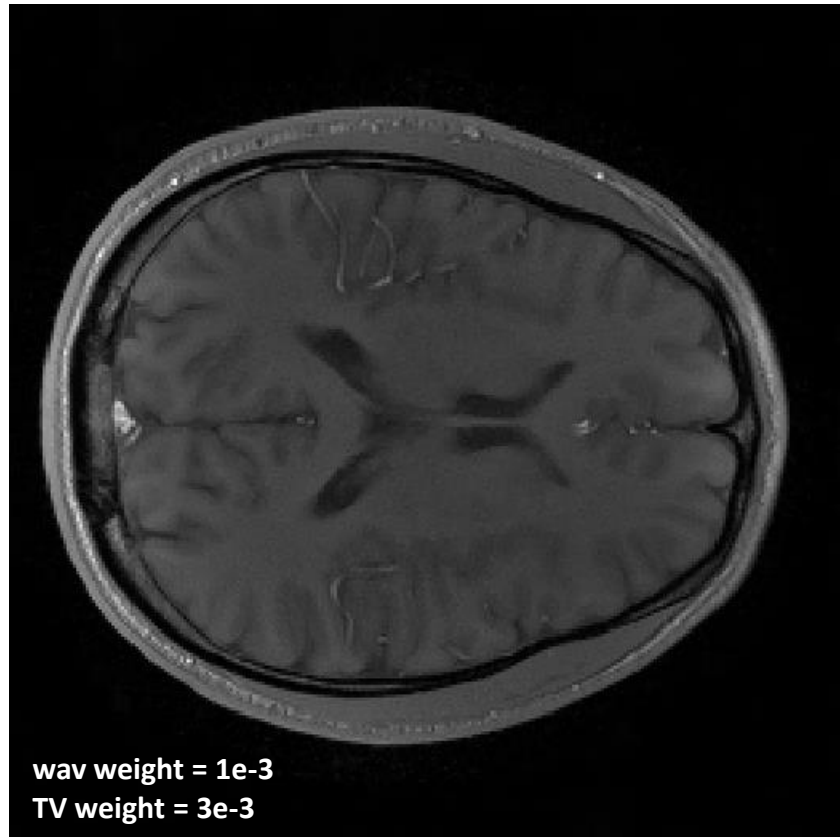
Ground Truth



Sparse SENSE



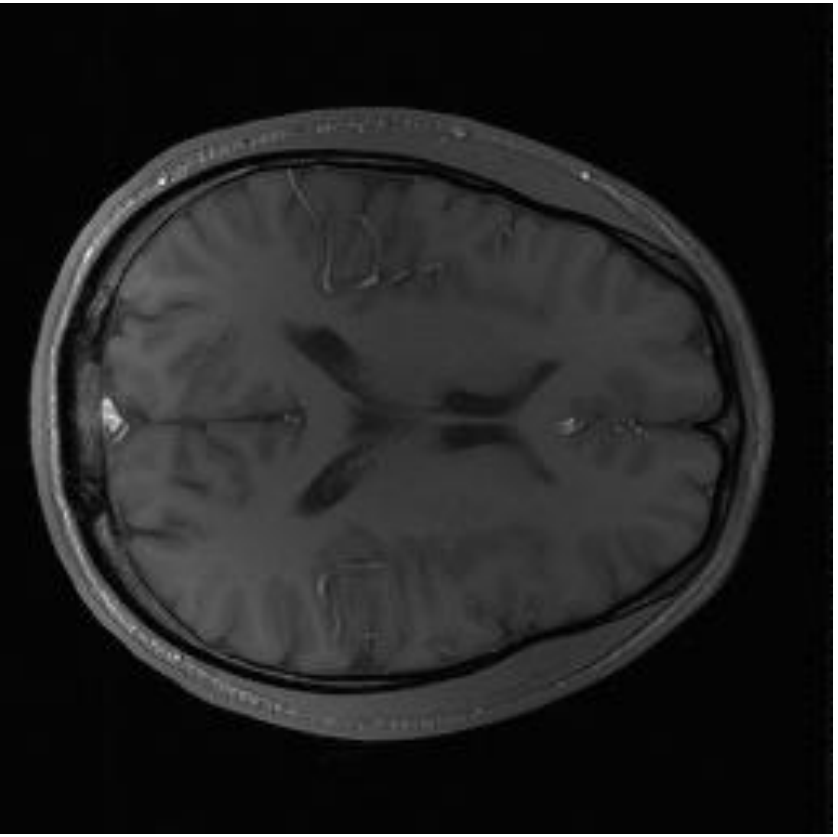
CS SENSE



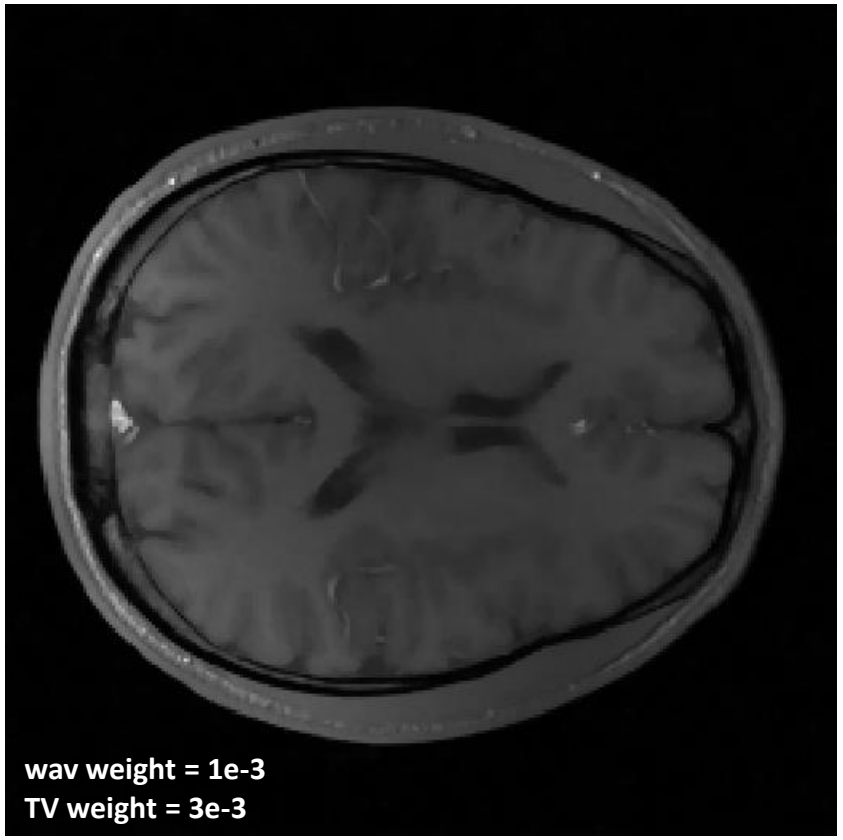
Iteration : 80
Alpha = 0.05
Beta = 0.6
Smoothing factor : 1e-6
mask $\propto R^2, 0.3$

1.4. Figure 6

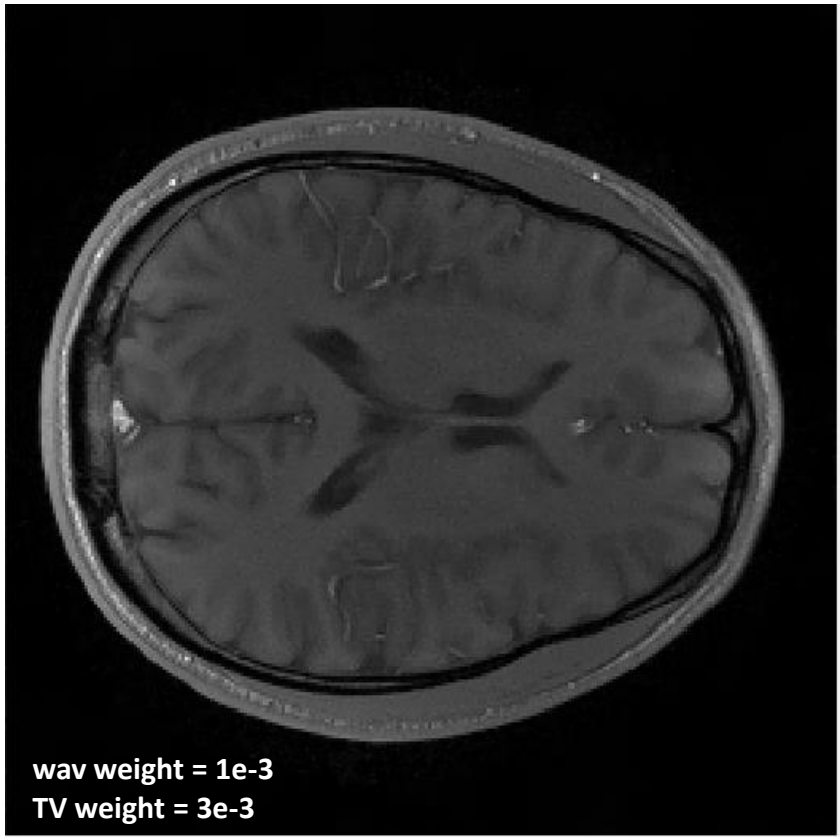
Ground Truth



Sparse SENSE



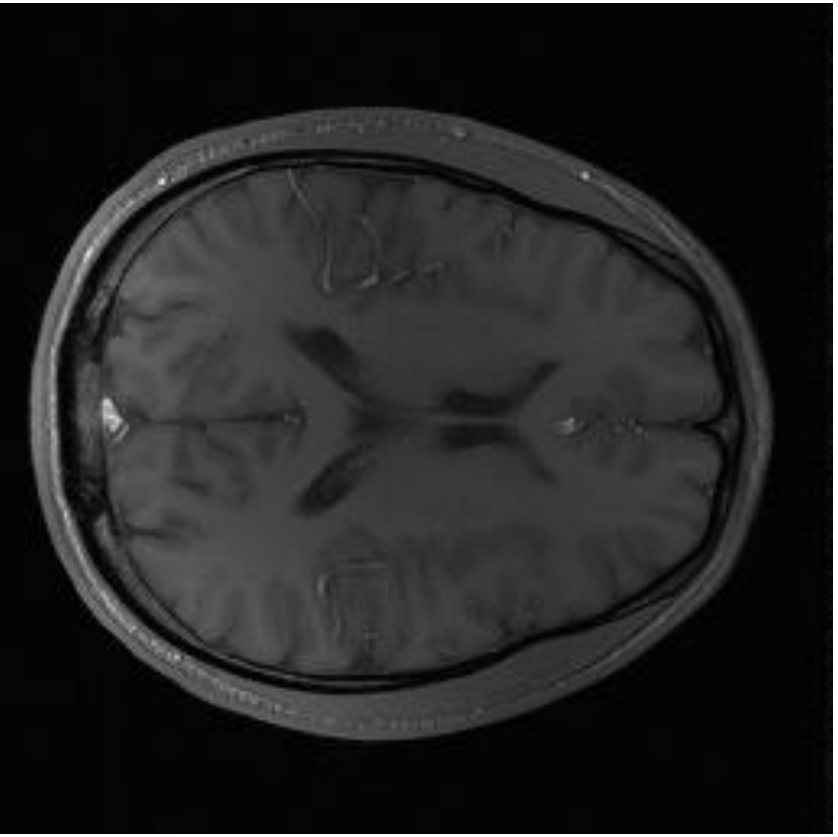
CS SENSE



Iteration : 80
Alpha = 0.05
Beta = 0.6
Smoothing factor : 1e-6
mask $\propto R^3, 0.25$

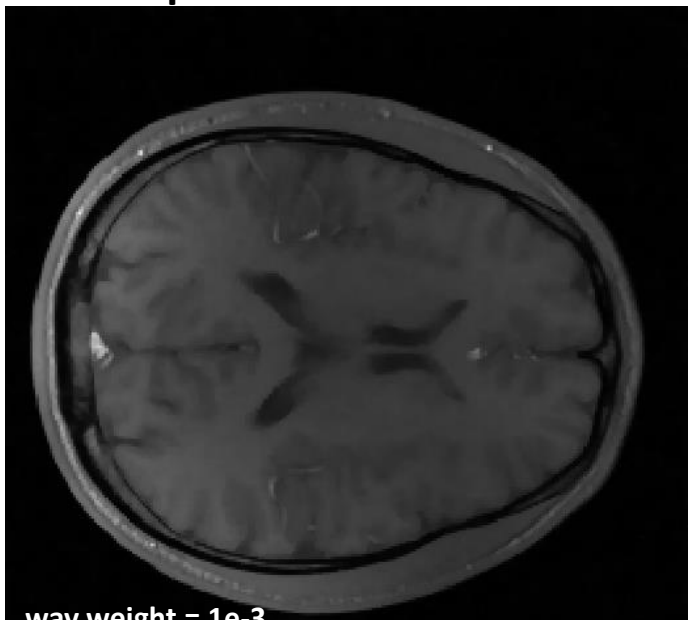
1.4. Figure 6

Ground Truth

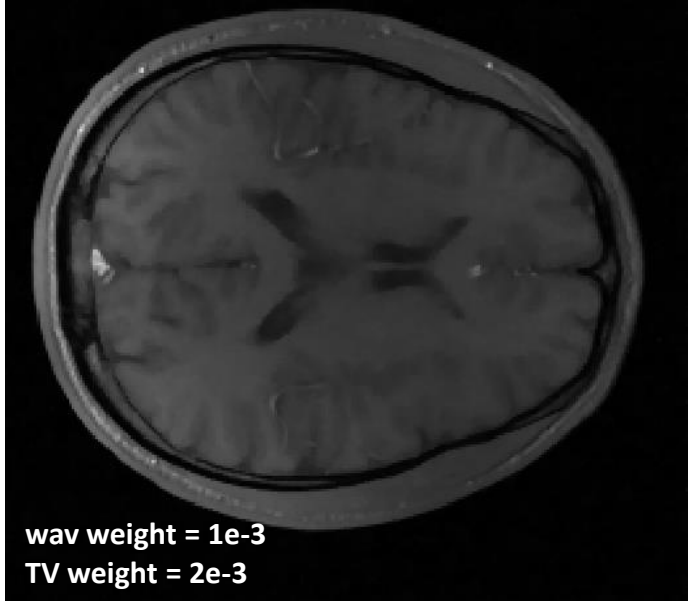


Iteration : 80
Alpha = 0.05
Beta = 0.6
Smoothing factor : 1e-6
mask $\propto R^3, 0.2$

Sparse SENSE

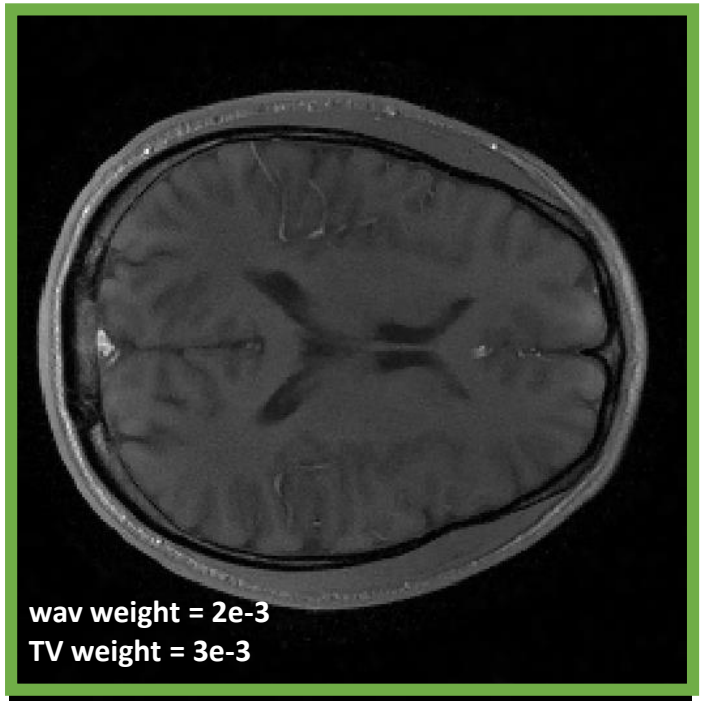


wav weight = 1e-3
TV weight = 3e-3

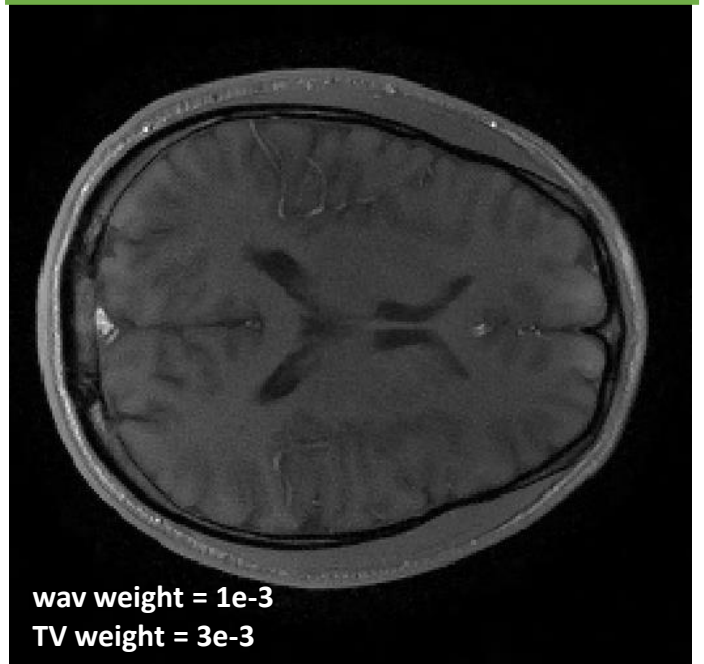


wav weight = 1e-3
TV weight = 2e-3

CS SENSE

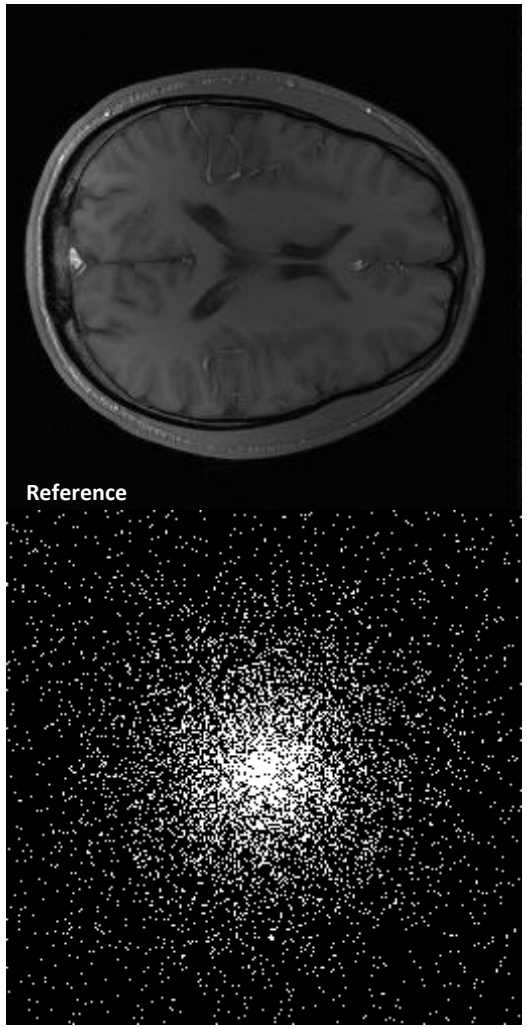


wav weight = 2e-3
TV weight = 3e-3



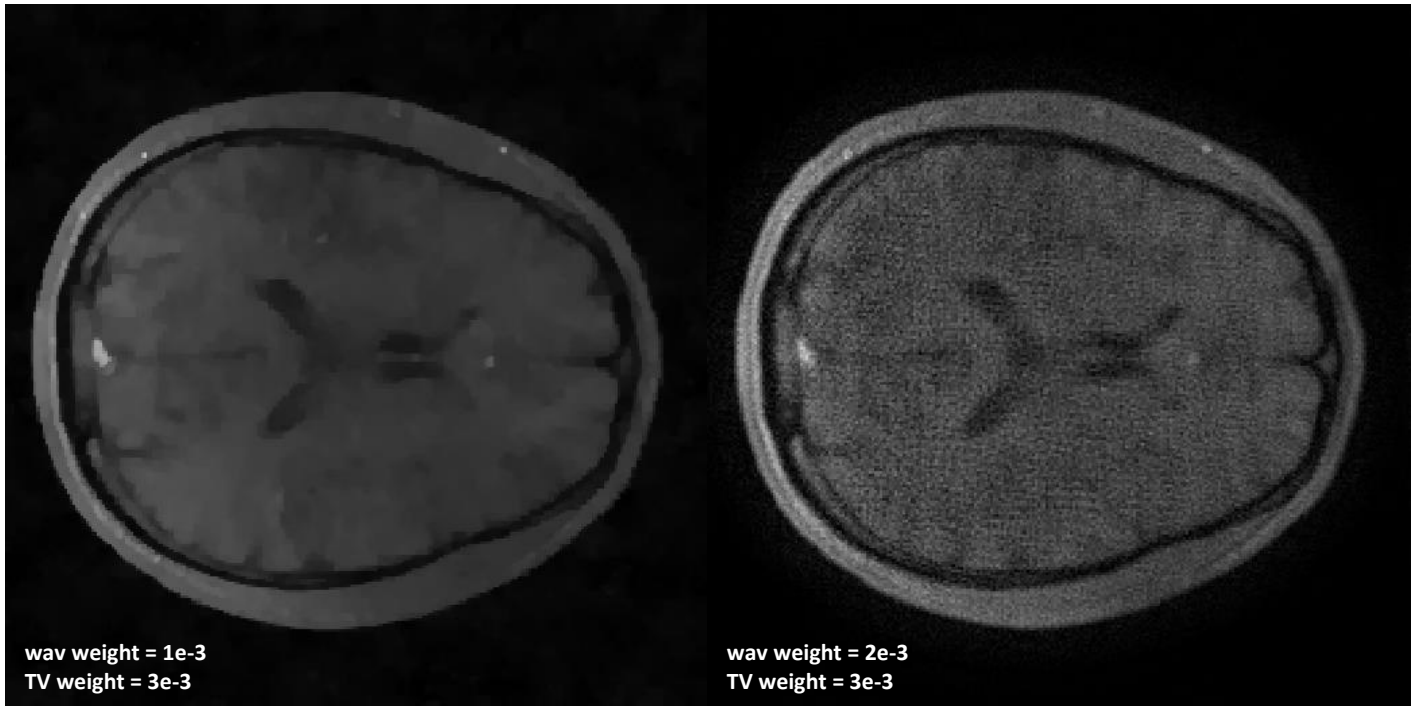
wav weight = 1e-3
TV weight = 3e-3

1.4. Figure 6



SparseSENSE

CS SENSE



Iteration : 80
Alpha = 0.05
Beta = 0.6
Smoothing factor : 1e-6
mask $\propto R^5, 0.1$