Research of Magnetic Particle Imaging Reconstruction based on the Elastic Net Regularization

Xiaojun Chen
  Beijing Institute of Technology

Xiao Han
  Beijing Institute of Technology

Xiaolin Wang
  Beijing Institute of Technology

Xiaoying Tang (✉ xiaoying@bit.edu.cn)
  Beijing Institute of Technology

Research

Abstract

Background: MPI is an emerging medical imaging modality which is based on the non-linear response of magnetic nanoparticles. The reconstruction task is an inverse problem and ill-posed in nature. Methods: To overcome the problem, we propose to use the EN regularization model. In order to reach a good result with a short reconstruction time, we use the truncated system matrix and the truncated measurement for reconstruction research.

Results: In this paper, we study the reconstruction quality of different threshold values and different regularization parameter values. We compare the reconstruction performance of the proposed model with the Tikhonov model and the LASSO model from visualization and performance indicators. Compared with the Tikhonov model and LASSO model, the MPI reconstruction results based on EN were with smaller MSE, higher PSNR/SSIM, and the reconstruction time was much shorter than the Tikhonov model and LASSO model. EN-based reconstruction with almost no artifacts.

Discussion: The traditional Tikhonov regularization smooth out the edges with the limited noise suppression ability. The LASSO algorithm overcomes these drawbacks through a prior based on the $l1$ norm with stronger noise suppression capabilities and better edges retention ability. Although the LASSO has shown success in many situations, it has some limitations. The EN method is an extension method of LASSO model, which overcomes the limitations of the LASSO in scenarios above. Compared with LASSO, the EN adds the $l2$ norm constraint on the basis of the $l1$ norm, which is a relatively gentle learning model

Conclusion: The conducted study illustrated that the proposed method yields significantly higher reconstruction quality than the state-of-the-art reconstruction method based on Tikhonov model and LASSO model.

Full Text

Due to technical limitations, full-text HTML conversion of this manuscript could not be completed. However, the latest manuscript can be downloaded and accessed as a PDF.
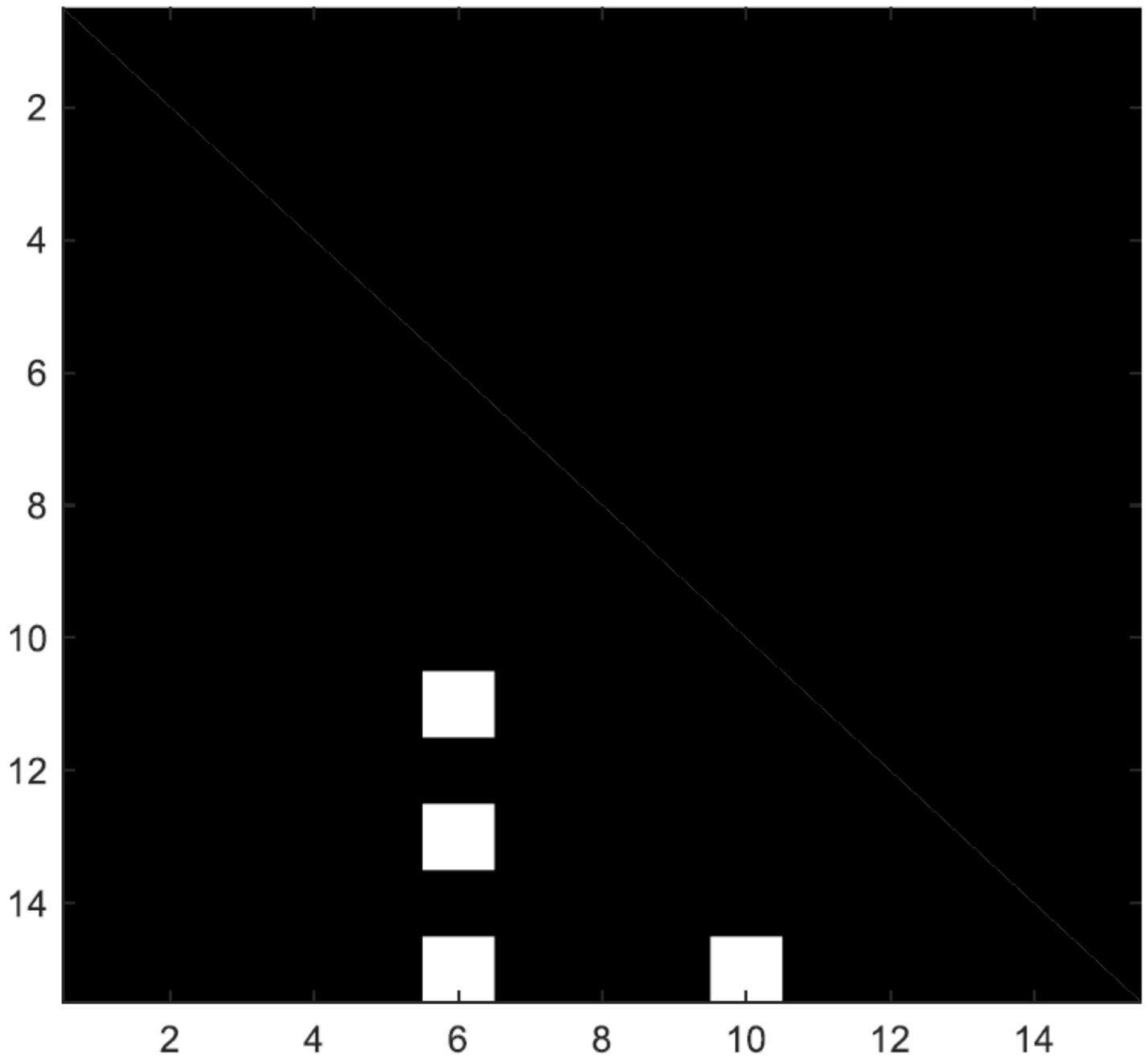
Figures

Figure 1
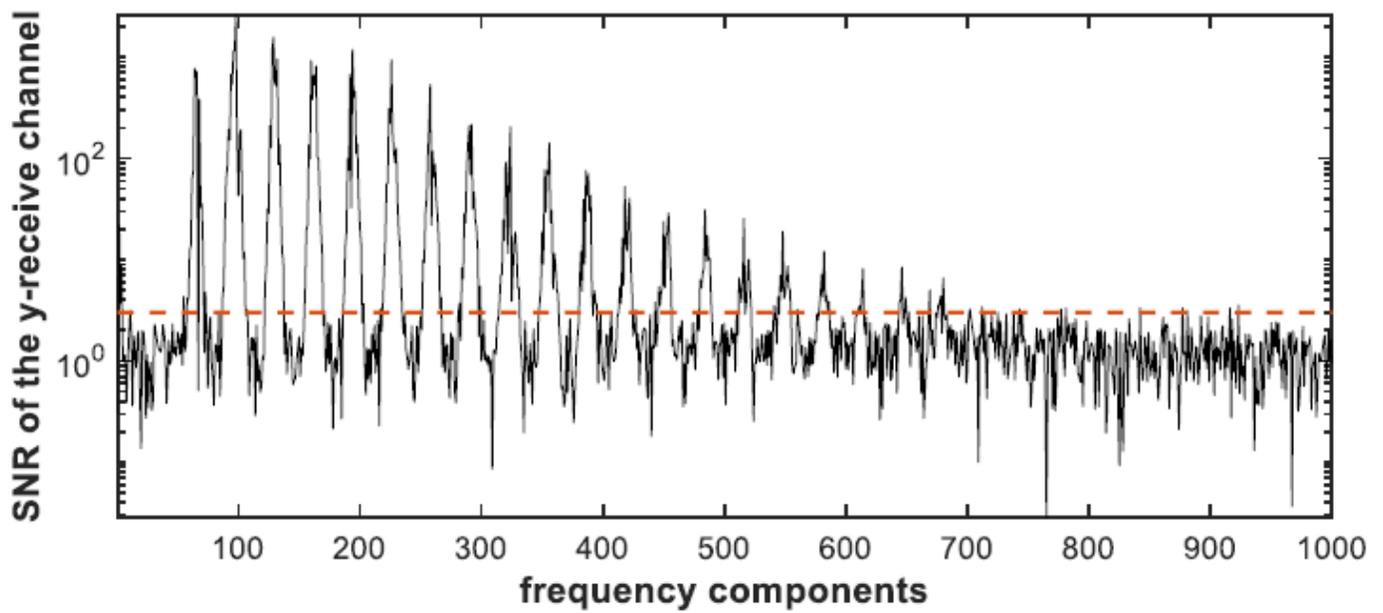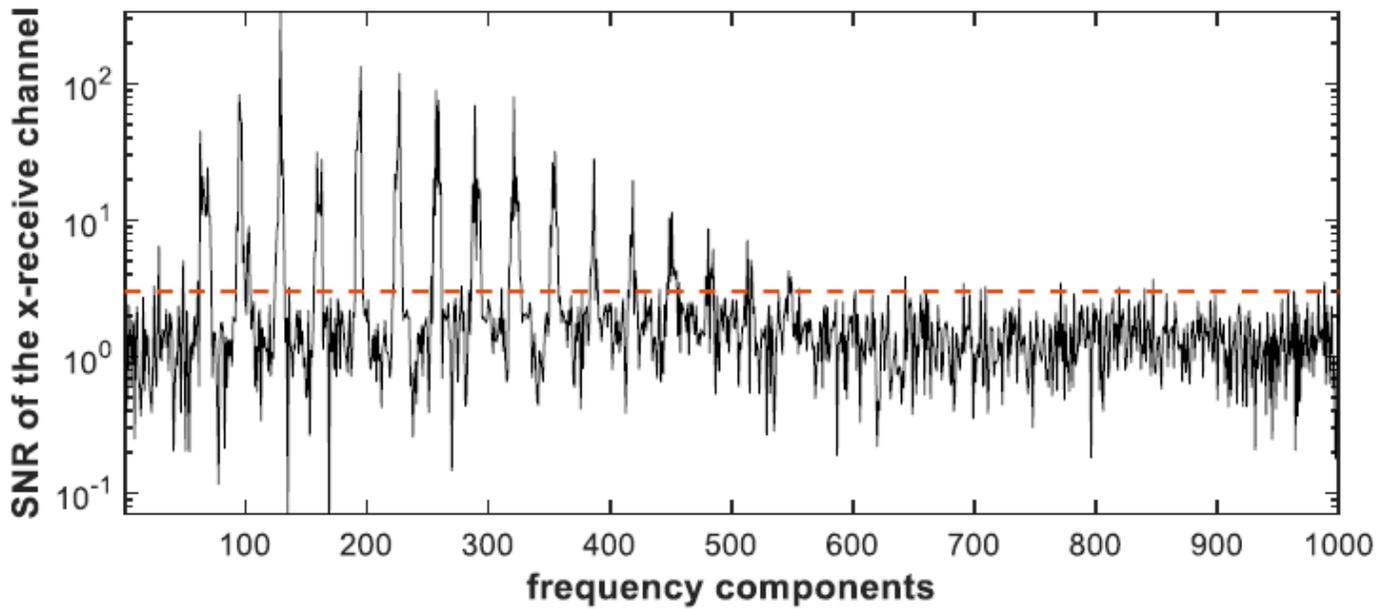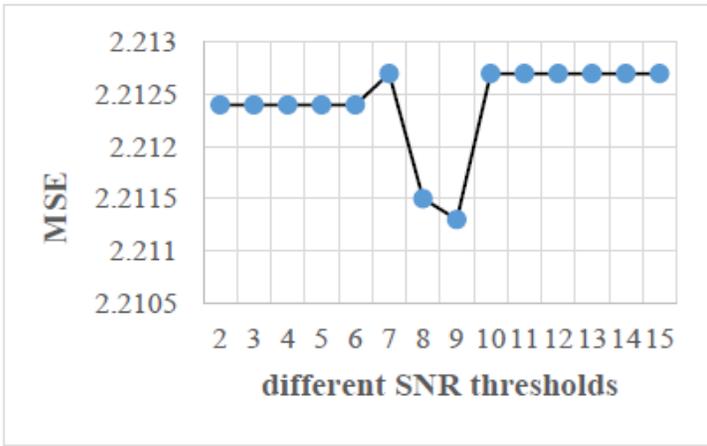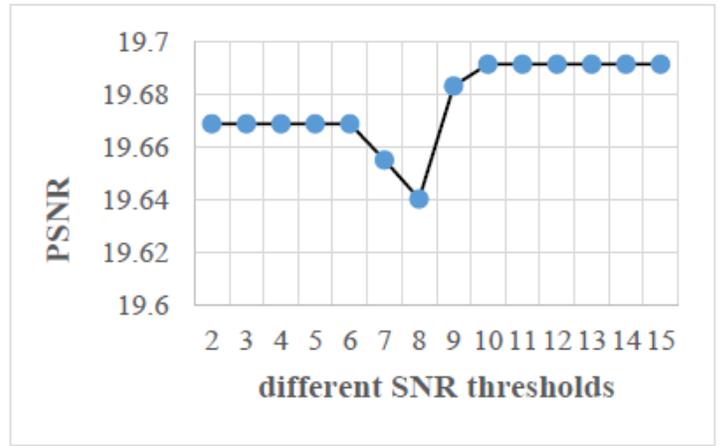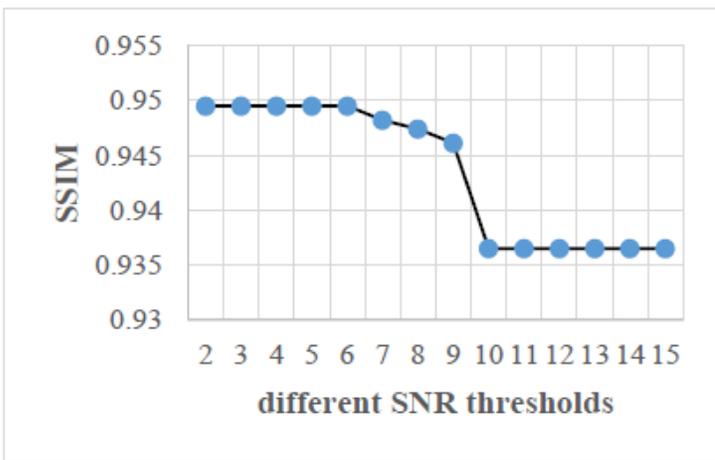
The corresponding phantom.

Figure 2

The SNR of the different frequency component for the x- and y-receive channel. The dashed line illustrates the SNR thresholds. (adapted from [6])
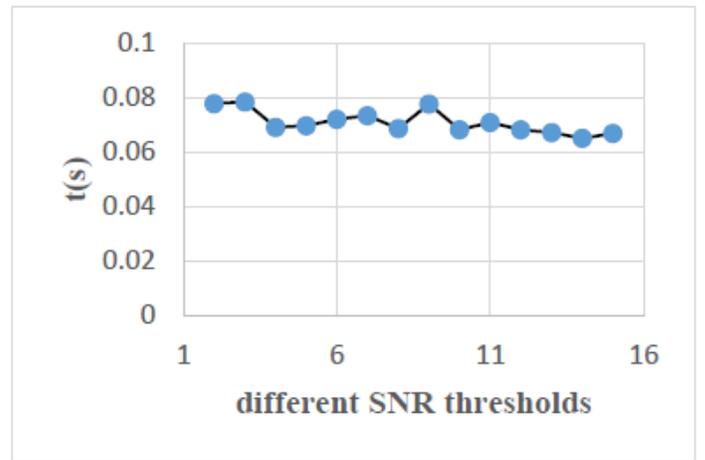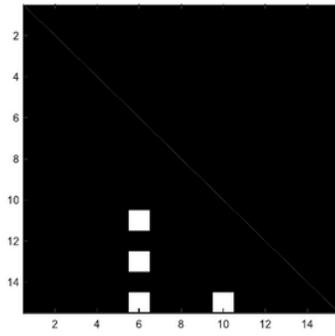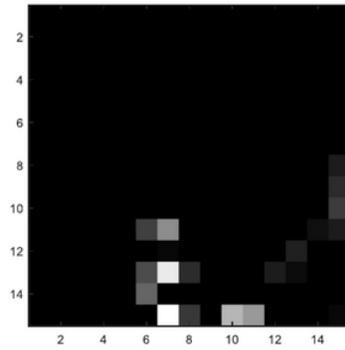
a) MSE

b) PSNR
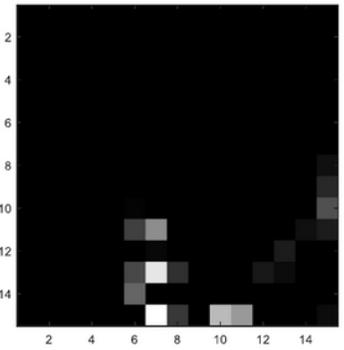
c) SSIM

d) t

Figure 3

Reconstruction quality based on Tikhonov regularization with different thresholds a) MSE b) PSNR c) SSIM d) t

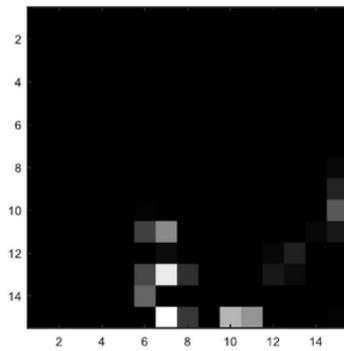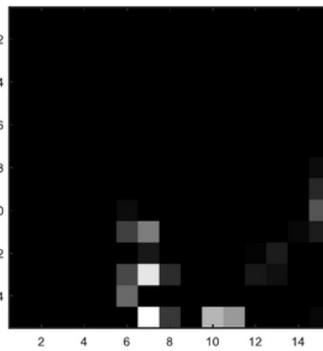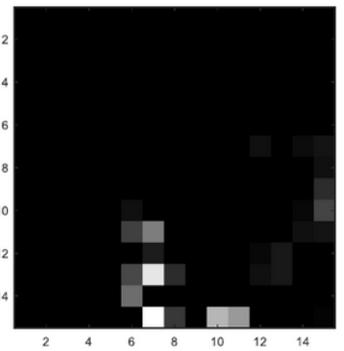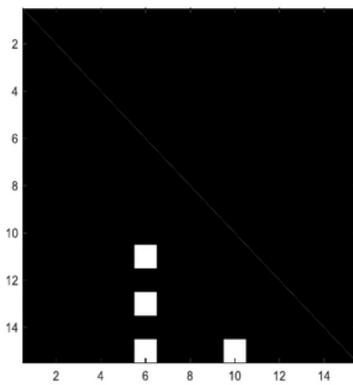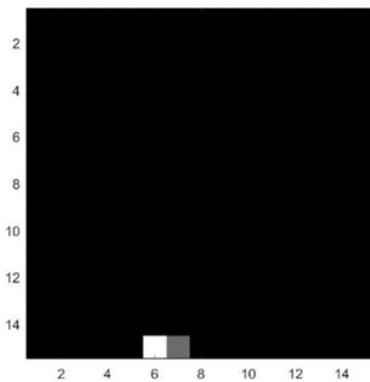a)   b)   c)
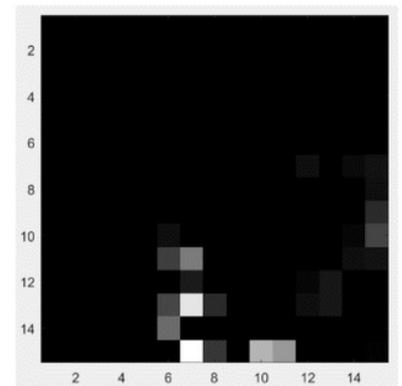
d)   e)   f)

Figure 4

Reconstruction results based on Tikhonov regularization with different thresholds a) the phantom b) SNR threshold is set to 6 c) SNR threshold is set to 7 d) SNR threshold is set to 8 e) SNR threshold is set to 9 f) SNR threshold is set to 10

a)   b)   c)

Figure 5

Comparison of the reconstruction results based on LASSO and Tikhonov model. a) the corresponding phantom b) reconstruction based on LASSO regularization (β =0.02) c) reconstruction based on Tikhonov model (λ 5.86 x 10-6)

a)

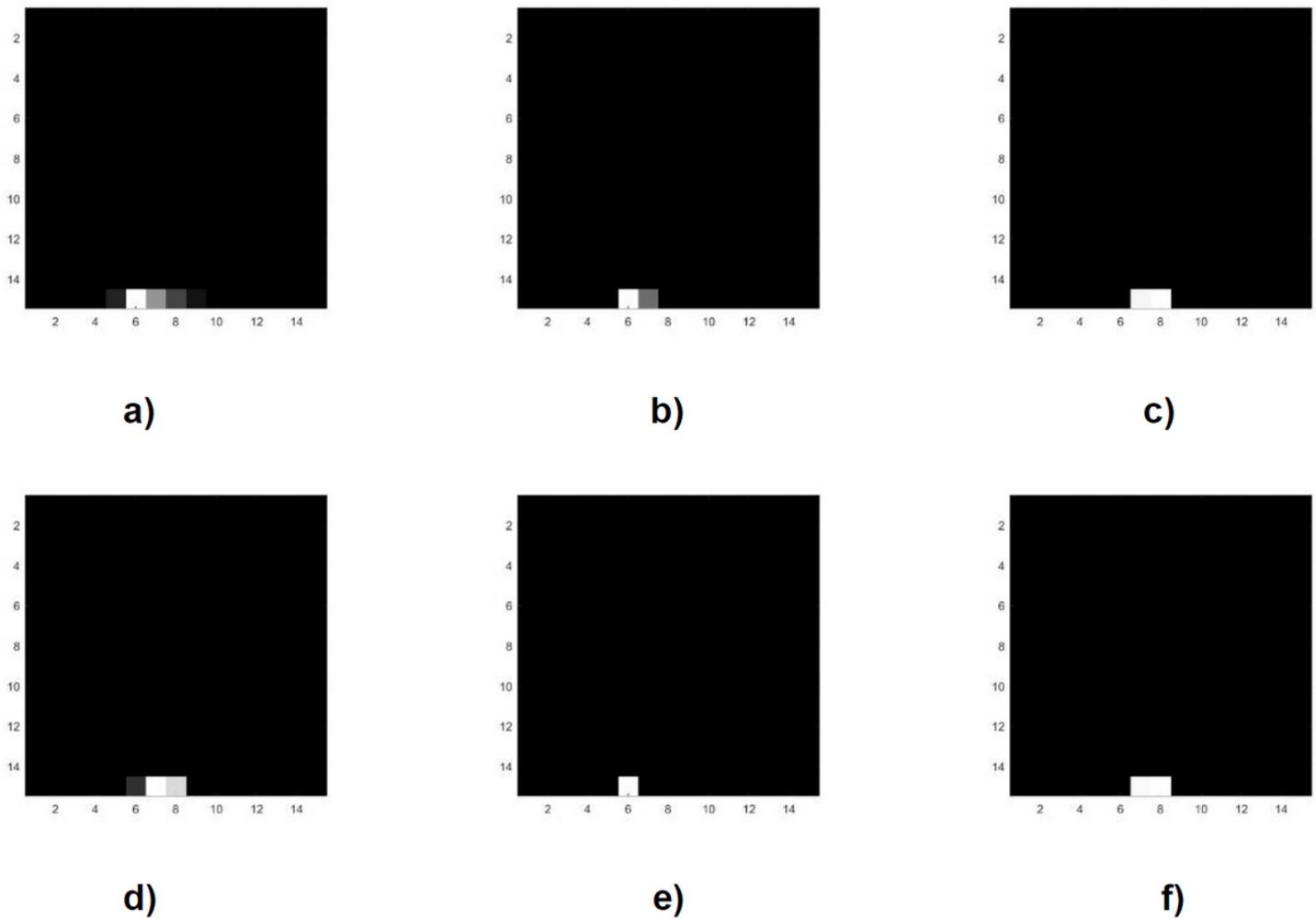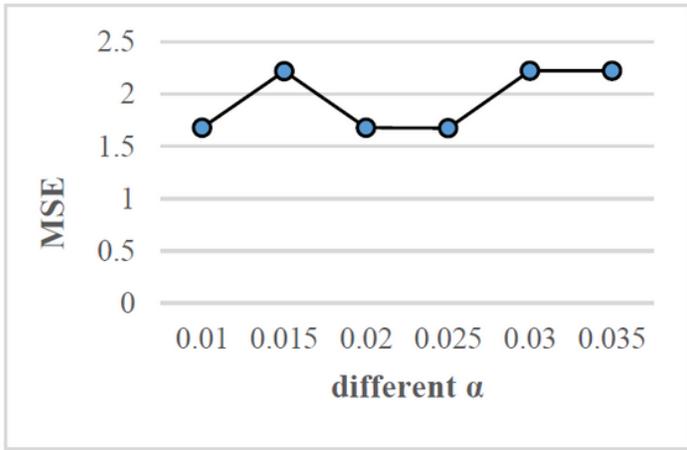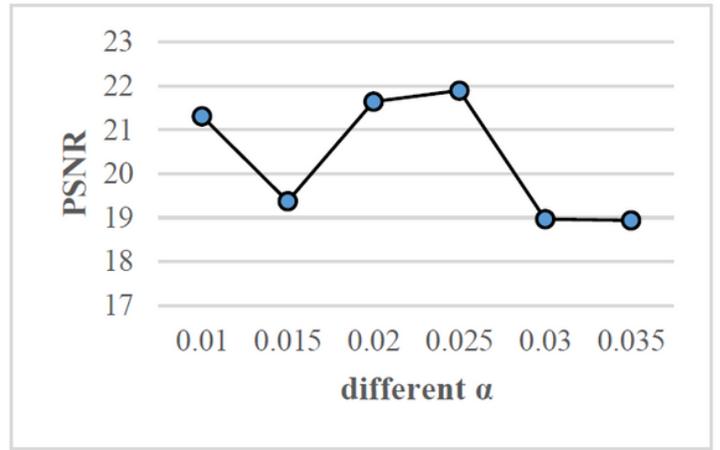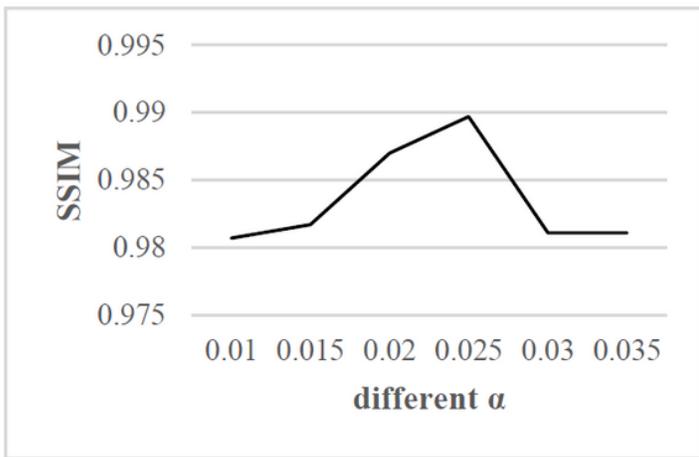b)

c)

d)

e)

f)

Figure 6

Different reconstruction quality based on EN with different α on the basis of β =0.02 a) α=0.01 b) α=0.015 c) α=0.02 d) α=0.025 e) α=0.03 f) α =0.035
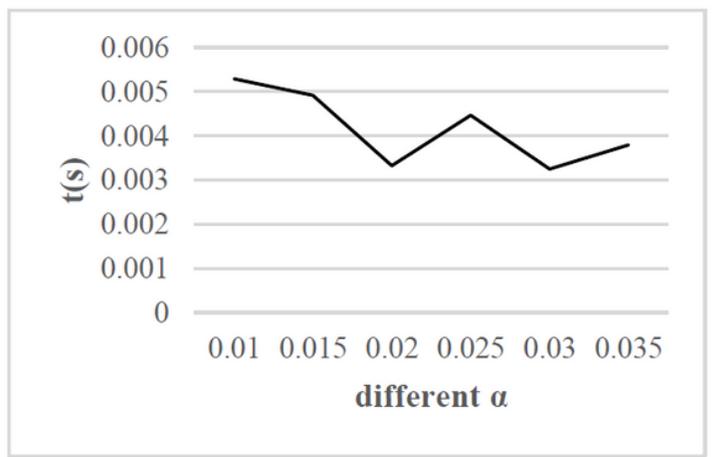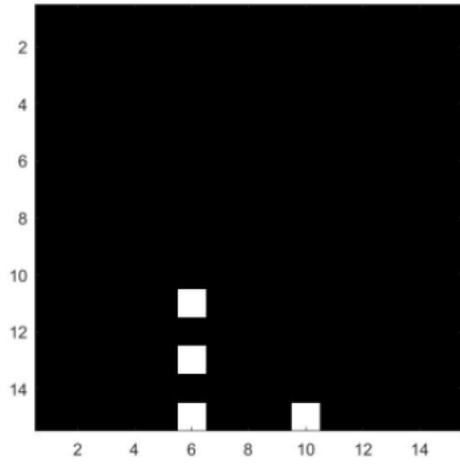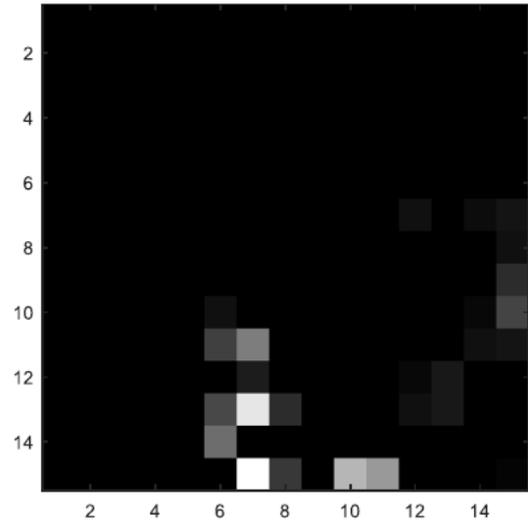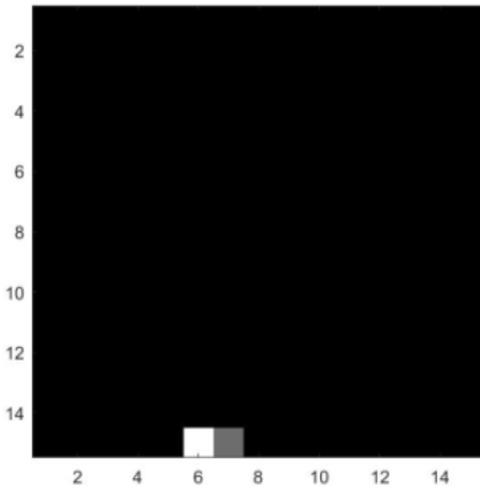
a) MSE

b) PSNR

c) SSIM

d) *t*

Figure 7

Different reconstruction quality based on EN with different α on the basis of β =0.02
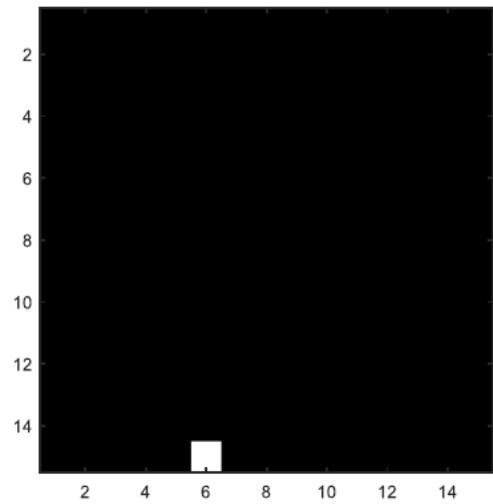
a)

b)

c)

d)

Figure 8

Comparison of the reconstruction results. a) the corresponding phantom b) reconstruction result based on Tikhonov model ($\lambda = 5.86 *10^{-6}$) c) reconstruction result based on LASSO regularization (β =0.02) d) reconstruction result based on EN regularization (α=0.025, β =0.02)
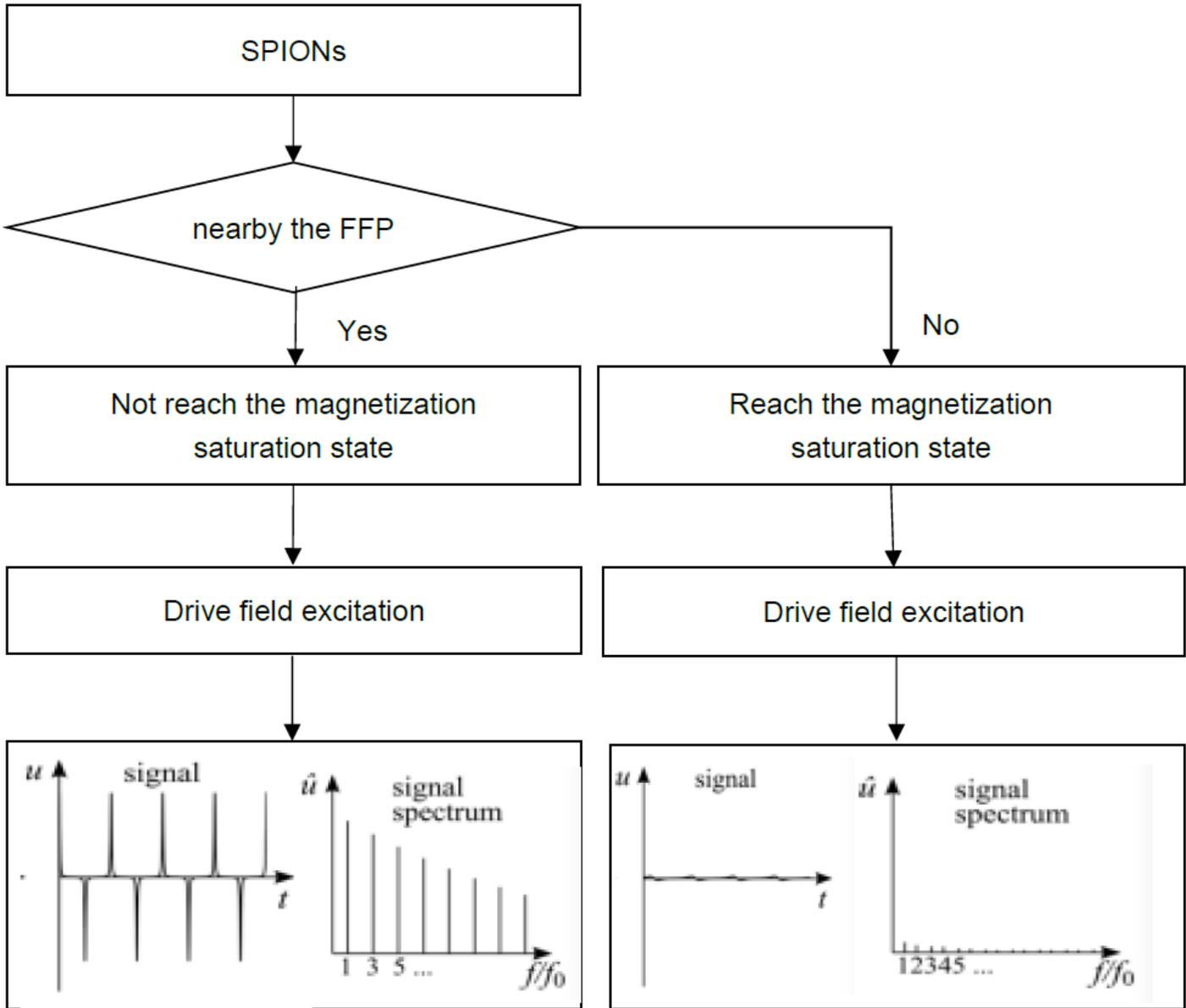
Figure 9

The basic imaging principle of MPI