

X-ray tomography with matrices

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This page contains the computational Matlab files related to the book [Linear and Nonlinear Inverse Problems with Practical Applications](#) written by Jennifer Mueller and Samuli Siltanen and published by SIAM in 2012.

You can order the book [at the SIAM webshop](#).

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Here we construct the measurement matrix A related to tomographic imaging and solve the inverse problem using several regularized methods. These routines make heavy use of `radon.m` and `phantom.m` files that are available only in Matlab's Image processing toolbox, not in the basic version of Matlab.

Constructing the measurement matrix A

This Matlab routine builds the tomographic measurement matrix for $N \times N$ images and N uniformly distributed parallel-beam projections:

[XRMA_matrix_comp.m](#)

You can choose your favorite value of N inside the above m-file. Note that taking N greater than 64 will choke most personal computers either here or later when computing the singular value decomposition of A ! The examples on this page are meant to be studied at low dimensions, such as N between 16 and 50, say.

The matrix is saved to your working directory as a `.mat` file. The number N is part of the filename, as you can see in these example files:

[RadonMatrix16.mat](#), [RadonMatrix32.mat](#)

Creating data that contains inverse crime

You can try out naive inversion involving inverse crime with the following routines:

[XRMB_naive_comp.m](#), [XRMB_naive_plot.m](#)

Creating data without inverse crime

These routines interpolate the data from a higher-dimensional model.

[XRMC_NoCrimeData_comp.m](#), [XRMC_NoCrimeData_plot.m](#)

You can go ahead and see how naive inversion fails again:

[XRMD_naive_comp.m](#), [XRMD_naive_plot.m](#)

Regularized inversion using truncated SVD

Compute the singular value decomposition:

[XRME_SVD_comp.m](#), [XRME_SVD_plot.m](#)

Now we can use the truncated SVD to achieve robust reconstructions:

[XRMF_truncSVD_comp.m](#)

Tikhonov regularization

Compute Tikhonov regularized reconstructions with these routines:

[XRMG_Tikhonov_comp.m](#), [XRMG_Tikhonov_plot.m](#)

You can experiment by varying the regularization parameter.

Approximate total variation regularization

Here we reconstruct the attenuation coefficient using total variation regularization. We smooth the non-differentiable corner of the absolute value function appearing in the total variation norm, resulting in a smooth objective functional to be minimized. The optimization method we use is the Barzilai-Borwein method.

[XRMH_aTV_comp.m](#), [XRMH_aTV_plot.m](#).

You will need all of the files below to run the above reconstruction routine:

[XRMH_aTV_feval.m](#), [XRMH_aTV_fgrad.m](#), [XRMH_aTV_grad.m](#), [XRMH_aTV.m](#), [XRMH_misfit_grad.m](#), [XRMH_misfit.m](#)