

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING  
NORTHEASTERN UNIVERSITY

ECE U692 INTRO TO SUBSURFACE SENSING AND IMAGING Spring 2004

Homework Set 4 Supplement

**Due:** By the start of class on Mon. Mar. 29

This is a supplement explaining some details about how to do the second and third parts of HW 4. Note the modified due date above. To do these parts of the homework, you should first get the MVT (multi-view tomography) Toolbox from the link on the course web page. Unzip (or gunzip and untar, as you choose) this file. Read through the file `mvt_demo.m` for step-by-step instructions on how to use the software to create a Born model forward matrix and the Born-predicted incident (or background-only fluence. The quickest way to get questions about this software answered is to email them to Jennifer Black ([jblack@ece.neu.edu](mailto:jblack@ece.neu.edu)) **and** both Prof. DiMarzio and Prof. Brooks.

It is *critical* that you pay careful attention to how you set up the geometry of the problem. The detector locations used in creating your Born model should be at the center of the CCD pixels you average to get your measurements. The source locations should be accurate. Moreover, in order for the Born matrix to correspond to your geometry and your data, you need to order the sources and detectors by varying  $y$  first, then  $x$ , as shown by the order used in the files `sources.txt` and `detectors.txt` distributed with the software. The voxels, when put into a long vector for use with the Born model, will be assumed to vary by  $y$  first, then by  $x$ , then by  $z$ . In other words, if you discretize your volume into a grid that is  $5 \times 4 \times 3$  (not the recommended values, just an example), then your vector will be of length 60, the first 20 values will be the top (in  $z$ ) layer, and the last 20 the bottom layer.

To give you some assistance with checkpointing your progress, we have made available on the course web site:

1. A sample data set taken by Tianchen Shi. Just the differences between the background (no-target) and with-target measurement are posted. The file contains a single matrix with 702 rows and 3 columns. Each column corresponds to one wavelength, and the 702 rows correspond to 6 sources by a  $9 \times 13$  synthesized array of detectors as described in the original problem statement. The first 113 rows are the first source position, etc. Note that you are to base your own homework on your own data, not this data set. We are posting this one only to give you some opportunity to checkpoint your own work.
2. A plot of the singular values for one wavelength for a Born matrix computed for the geometry provided for that data set by Tianchen. Note that the volume was discretized

into 350 voxels ( $10 \times 7 \times 5$ ), starting from a second layer in  $z$ —the top layer of voxels was just ignored. Since the Born model only looks at perturbations from the background, if we assume there are no inhomogeneities in the top layer we are safe to do this. This has no meaningful effect, it just saves on computations.

3. A plotting m-file, `slice5plots.m`, which will plot 5 horizontal “slices” at 5 depths as images. Read the help in the m-file for instructions on usage. Feel free to modify this to match your own geometry. Note that I have written it so that the same colormap is used on all slices. This is important in visual evaluation of the results—try plotting without this little wrinkle to see the difference!

Below are plots of reconstructions for both the Tikhonov and TSVD methods for this same geometry at one wavelength (590 nm) for one value of the regularization or truncation parameter for each case. These were just quickly-chosen values, and we are posting these results to give you some idea of what you might expect to achieve. If you play with the various parameters in setting up the problem (for example, the way the detectors are synthesized from the CCD array and the way that the volume is discretized into voxels), as well as with the parameters of the regularization, you may achieve better results. However in the plots below you can see the existence and the general locations of the two inhomogeneities.

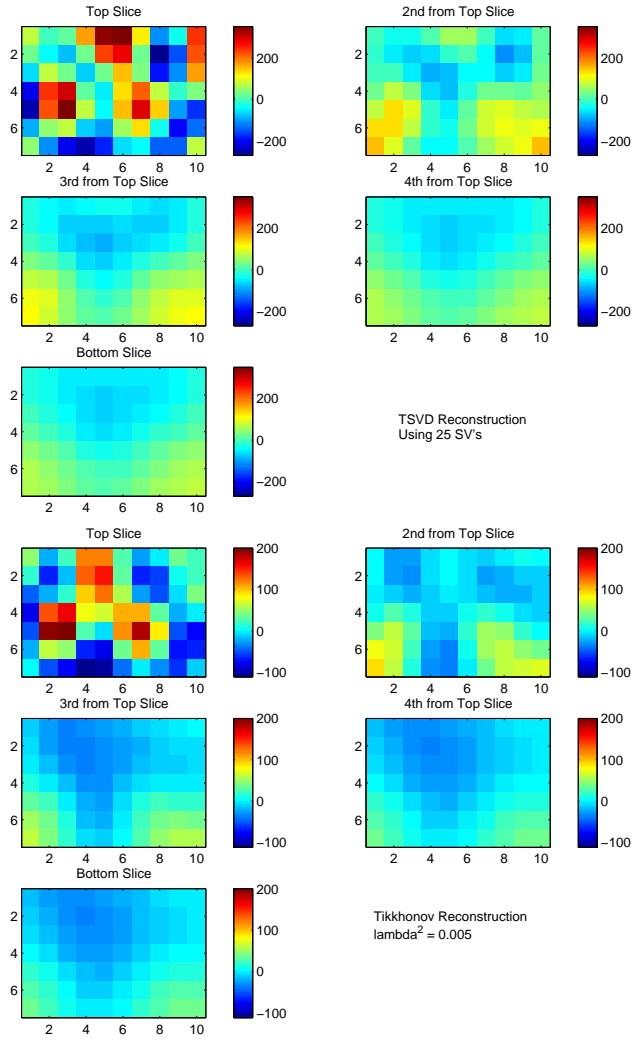


Figure 1: TSVD and Tikhonov reconstructions at 590 nm, with the geometry parameters as described in the text.