MAT-63506 Programming projects
Plotting the Pseudo Spectrum of a Matrix
User's Guide

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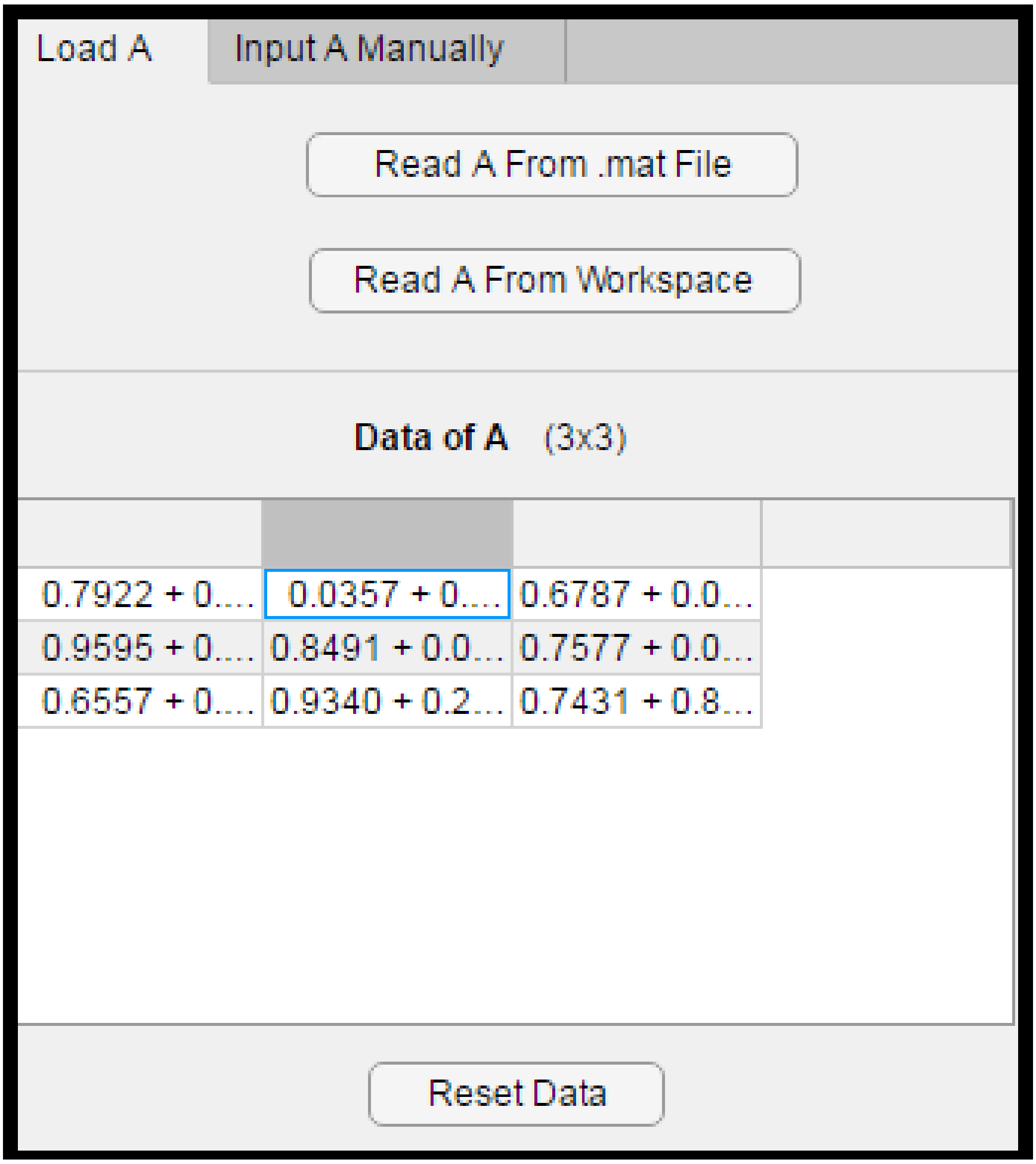
1 Instructions

1.1 Input Methods for Matrix A

1.1.1 Loading the Matrix

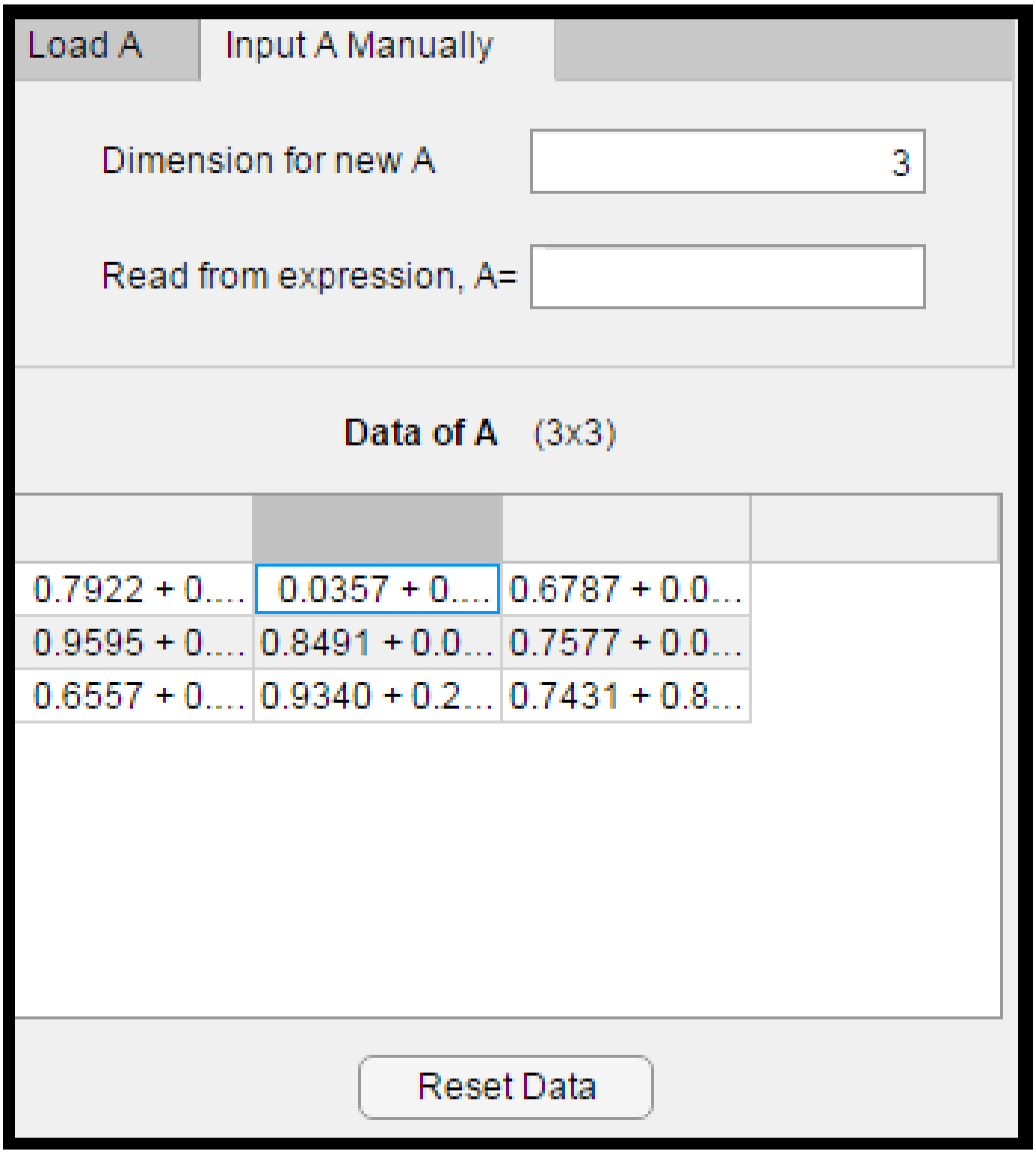


0.7922 + 0....	0.0357 + 0....	0.6787 + 0.0...
0.9595 + 0....	0.8491 + 0.0...	0.7577 + 0.0...
0.6557 + 0....	0.9340 + 0.2...	0.7431 + 0.8...

Figure 1: Loading data from matrix A

Different methods of loading matrix A are shown on the right corner of the application window. The first one is to read it directly from a *.mat file. A sample file named ‘AFile.mat’ has been placed in the working directory for testing, which contains the matrix used in the documentation. Another method is to read the matrix from Matlab workspace.

1.1.2 Input the Matrix manually



Dimension for new A 3

Read from expression, A=

Data of A (3x3)

0.7922 + 0....	0.0357 + 0....	0.6787 + 0.0...
0.9595 + 0....	0.8491 + 0.0...	0.7577 + 0.0...
0.6557 + 0....	0.9340 + 0.2...	0.7431 + 0.8...

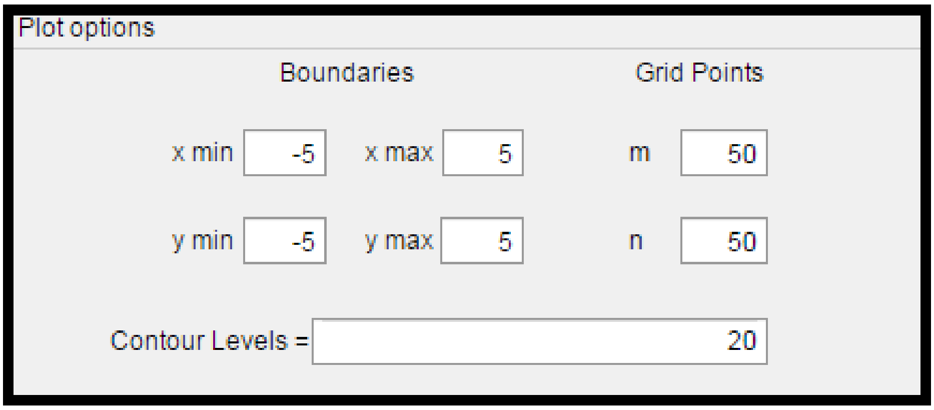
Figure 2: Input A manually

It is also possible to input the matrix A manually to the program. This can be done either as an expression or through modifying the values in the UITable, which at all times also displays the content of A. User can input “Dimension for new A”, after which the matrix is reset to a zero matrix with the given dimension. “Reset Data” button resets all the values of A to 0.

1.1.3 Error and Limitation

To plot the matrix data must be numeric, if you try to put anything different from a square numeric matrix, the application will return an error. The size is unlimited for the matrix A, however, a large one could take a long time to compute.
One small problem when using load from file function is that the screen might jump to another window. However, the matrix is still loaded like normal, it is just a strange phenomenon.

1.2 Plot Options



Plot options

Boundaries

x min -5 x max 5

y min -5 y max 5

Grid Points

m 50

n 50

Contour Levels = 20

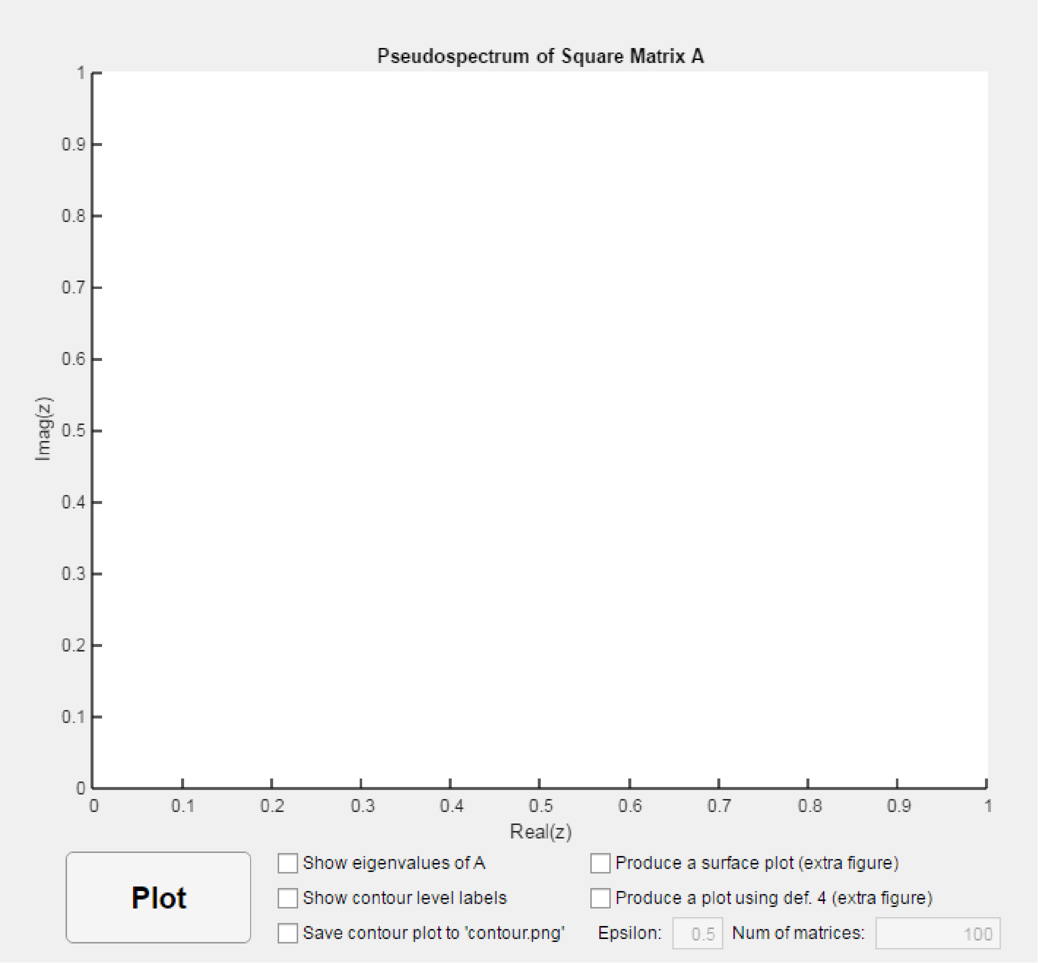
Figure 3: Plot options

It is possible to change some of the option to plot the function. These options only apply for the contour plot of the definition number (3).
For boundaries, min values must be smaller than max. For grid points, the values must be integer larger than 0.
Once again, there is no limitation in the numbers which you can input (except that they have to be numerical). However, it is not advisable to use numbers that are way too big .

The ϵ-values for the contour levels must be inputted as a row vector, if not then an error will be returned.

1.3 Plotting

1.3.1 Plotting with Definition (3)



☐ Show eigenvalues of A

☐ Show contour level labels

☐ Save contour plot to 'contour.png'

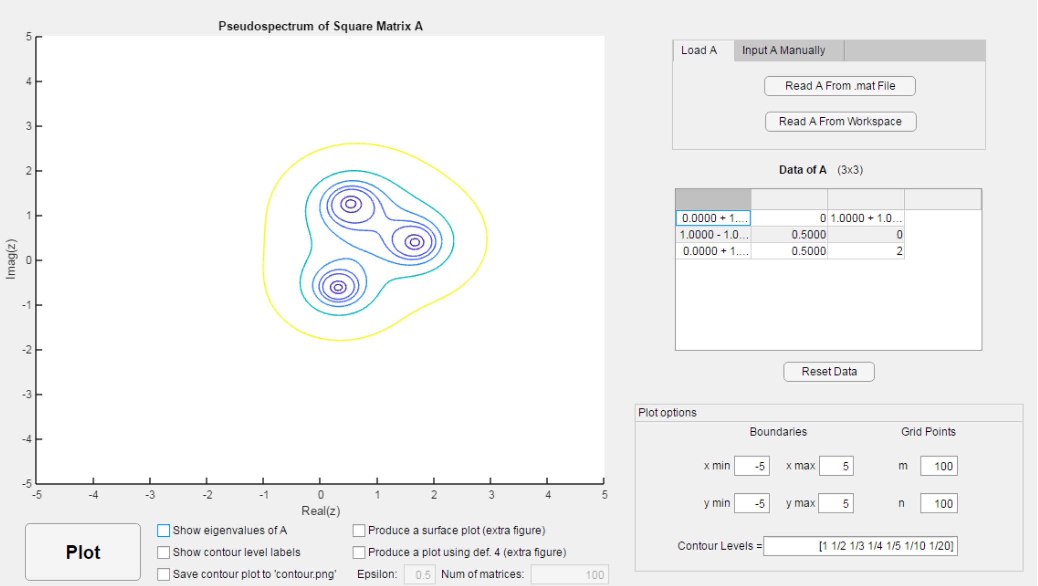
☐ Produce a surface plot (extra figure)

☐ Produce a plot using def. 4 (extra figure)

Epsilon: 0.5 Num of matrices: 100

Figure 4: Plot environment

Once the matrix has been implemented, and the options are set, it is time to plot the result. The basic result can be obtain by just clicking on the "Plot" button.



Data of A (3x3)

0.0000 + 1....	0	1.0000 + 1.0...
1.0000 - 1.0...	0.5000	0
0.0000 + 1....	0.5000	2

Plot options

Boundaries

x min -5 x max 5

y min -5 y max 5

Grid Points

m 100

n 100

Contour Levels = [1 1/2 1/3 1/4 1/5 1/10 1/20]

□ Show eigenvalues of A

□ Show contour level labels

□ Save contour plot to 'contour.png'

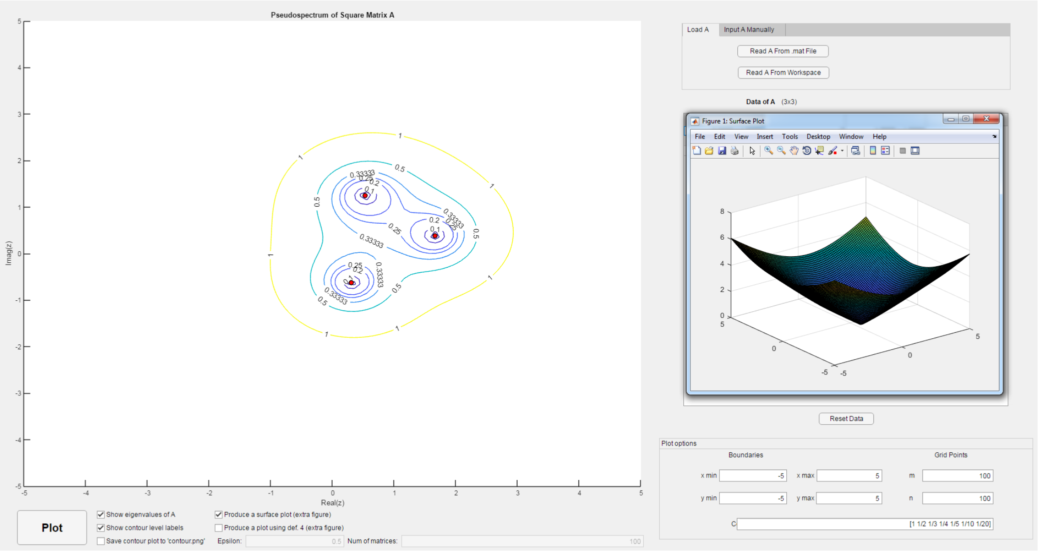
□ Produce a surface plot (extra figure)

□ Produce a plot using def. 4 (extra figure)

Epsilon: 0.5 Num of matrices: 100

Figure 5: Plot with default values and parameters

Additional features can be added when plotting the function. Simply check the one you want and use the "Plot" button to get the result. At any moment, you can stop the plotting by clicking once more on the plot button. However, you cannot resume the process, only restart it from the beginning.



Plot options

Boundaries

x min -5 x max 5

y min -5 y max 5

Grid Points

m 100

n 100

C [1 1/2 1/3 1/4 1/5 1/10 1/20]

☑ Show eigenvalues of A

☑ Show contour level labels

□ Save contour plot to 'contour.png'

☑ Produce a surface plot (extra figure)

□ Produce a plot using def. 4 (extra figure)

Epsilon: 0.5 Num of matrices: 100

Figure 6: Plot with additional features

1.3.2 Plotting with Definition (4)

Finally, it is also possible to plot the result with the other definition describe in the documentation. This one can be plotted by checking the corresponding tick box, and then input the options. The “Num of matrices” field represent the numbers of randomly generated matrix E use in the definition.

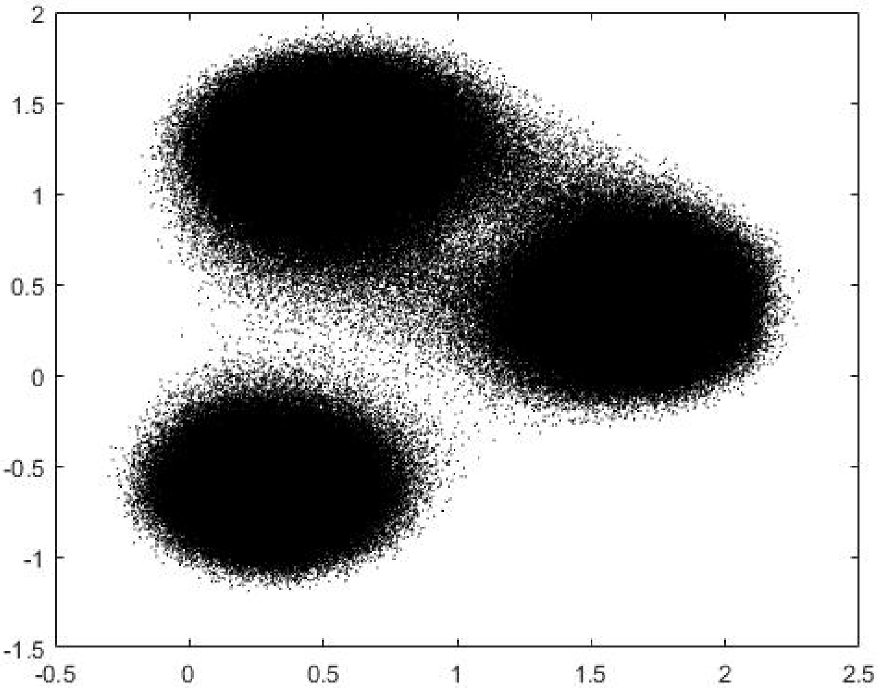


Figure 7: Plot using definition (4)

2 Code Explanation

To plot the pseudo-spectrum of a matrix using the definition (4), we had to implement a more complex equation. The basic idea is to generate matrices E, which have their norm somewhere between 0 and ϵ and plot the eigenvalues of matrices $(A + E)$. The ϵ-value and the number of matrices to generate are given to the program as inputs from the user.

The algorithm itself mainly consists of a for-loop in which we first generate a random complex matrix E. By multiplying this matrix with $\epsilon/norm(E)$

the norm becomes exactly ϵ, and multiplying again with rand (a random number between 0 and 1) makes the norm become somewhere between 0 and ϵ. Finally, eigenvalues of $(A+E)$ are calculated and added to the preallocated vector for eigenvalues.

The rest of the code are properly commented and can be understand easily just by reading through.