Computational Methods in Inverse Problems, Mat–1.3626

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Matlab Primer – How to Get Started

Matlab is a high level programming language particularly suitable for numerical linear algebra. The basic object in Matlab are matrices and vectors. To create arrays

$$x = \begin{bmatrix} 2 \\ -3 \\ 1 \end{bmatrix}, \quad A = \begin{bmatrix} 1 & 0 & 4 \\ -1 & 2 & 1 \\ -2 & 6 & 0 \end{bmatrix},$$

the comands are

```
x = [2;-3;1];
A = [1,0,4;-1,2,1;-2,6,0];
```

If you leave the semicolon at the end of the line out, Matlab echoes the array, which may be a good way to check that you did not do errors.

Matrix products and transposes: To calculate

$$y = Ax, \quad B = A^{\mathrm{T}},$$

type

```
y = A*x;
B = A';
```

To extract rows and columns from a matrix: Given the matrix A above, if you want the first column of A, or a submatrix containing only the first two rows of A, that is

$$\begin{bmatrix} 1 \\ -1 \\ -2 \end{bmatrix}, \quad \begin{bmatrix} 1 & 0 & 4 \\ -1 & 2 & 1 \end{bmatrix},$$

you may type simply

```
A(:,1)
A(1:2,:)
```

More generally, if C is a $n \times m$ matrix and you want to create a submatrix containing only j rows whose numbers you have collected to an index vector $I = [k_1, k_2, \ldots, k_j]$, write

```
C(I,:)
```

Conversely, if you want to merge two column vectors of same length into an array, try this:

```
a = [4;0;-1];
b = [1;2;0];
A = [a,b];
```

The result is a 3×2 array a and b as its columns.

Plot command in Matlab are versatile and of great help, e.g., when debugging a code. Suppose you want to plot the function $t \mapsto t\cos(\pi t)$, $0 \leq t \leq 1$. What you have to do is to form a vector discretizing the interval by n sampling points and another vector containing the function evaluations at those points:

```
n = 100;
t = linspace(0,1,n);
y = t.*cos(pi*t);
plot(t,y)
```

Notice the difference between the matrix product "`*`" and the pointwise multiplication of two vectors of equal size, "`*.`".

Solving linear systems: Let A be a square matrix of size $n \times n$ and b a column vector of size n. To find the n–vector x satisfying

$$Ax = b,$$

the Matlab command is

```
x = A\b;
```

If the matrix is not invertible or very ill-conditioned, Matlab lets you know (Try!). If you have a non-square matrix $A \in \mathbb{R}^{m\times n}$ and a column vector $b \in \mathbb{R}^m$, the command above returns the Least Squares Minimum Norm (LSQMN) solution, which can be written in terms of the pseudo-inverse of A,

$$x = A^{\dagger}b \in \mathbb{R}^n.$$

The Singular Value Decomposition (SVD) of a matrix,

$$A = UDV^{\mathrm{T}},$$

is obtained by the command line

```
[U,D,V] = svd(A);
```

Suppose you want to plot the singular values in a logarithmic scale. You may try the commands

```
d = diag(D);
plot(log(d));
```

giving you a curve plot. If you want to plot the singular values as red dots, you may try

```
plot(log(d),'r.','MarkerSize',15)
```

An automatic scaling to logarithmic scale, with slightly smaller blue dots, you get by typing

```
semilogy(d,'b.','MarkerSize',10)
```

More Matlab appears on these pages as the course goes on.