Introduction to MATLAB

2. Vectors and matrices

Georgios Georgiou

Department of Mathematics and Statistics

University of Cyprus

Πανεπιστήμιο Κύπρου
Τμήμα Μαθηματικών
και Στατιστικής

Definition of vectors and matrices

A vector $u = (u_1, u_2, \ldots, u_n)$ is introduced in MATLAB as follows:

>> $u=[\ u_1, u_2\ , \ldots, u_n\ ]$ or >> $u=[\ u_1\ \ u_2\ \ \ldots\ \ u_n]$

Matrices are defined in a similar manner using ';' or <Enter> to change a line.

```
>> u=[ 1 2  3]
u =
    1     2     3
>> v=[1,-2,4,5,-2]
v =
    1    -2     4     5    -2
>>
>> A=[1 -2; 3 4]
A =
    1    -2
    3     4
>> A=[1 3 -4 2
0,1,0,1]
A =
    1     3    -4     2
    0     1     0     1
>>
```

Matrix operations

Symbol	Operation
+	Addition
-	Substraction
*	Multiplication
\	Left division
/	Right division
^	Power

- the transpose A^T of a real matrix A, is denoted by A'
- Expressions

A*A*A and A^3

where A is a square matrix are equivalent.

- Scalar multiplication

x*A and x*u

- "Scalar division":

A/x and u/x

- "Scalar addition":

A – x and u + x

Left and right division

A\b	Solution of $Ax = b$
b/A	Solution of $xA = b$

Elementary matrices

function	
eye zeros ones rand randn pascal magic hilb invhilb	

1) eye(m,n) and eye([m n]) are equivalent.

2) ones(n) and ones(n,n) are equivalent.

See: help elmat

Defining vectors with a step

$$u = [u_1 : step : u_{last}]$$

$$u = u_1 : step : u_{last}$$

$$u = [u_1 : u_{last}]$$

$$u = u_1 : u_{last}$$

Last possible value

step=1

Όπως φαίνεται στο παράδειγμα που ακολουθεί η ίδια ιδέα μπορεί να χρησιμοποιηθεί για την κατασκευή πινάκων.

Παράδειγμα 2.3.2

Θα κατασκευάσουμε τους πίνακες

$$A=\begin{bmatrix} 1 & 2 & 3 & 4 & 5 \\ 10 & 8 & 6 & 4 & 2 \end{bmatrix} \quad \text{και} \quad B=\begin{bmatrix} 1 & 2 & 3 & 4 & 5 \\ 2 & 4 & 6 & 8 & 10 \\ 3 & 6 & 9 & 12 & 15 \end{bmatrix}.$$

```
>> A=[1:5;10:-2:2]

A =
     1     2     3     4     5
    10     8     6     4     2

>> B=[1:5;2:2:10;3:3:15]
B =
     1     2     3     4     5
     2     4     6     8    10
     3     6     9    12    15
```

Defining subvectors and submatrices

- A(i,j) → a_{ij}
- то A(:,j) → j column of *A*
- A(i, :) → i line of *A*
- A(m:n,p:s) → submaxtrix
- то A(end,:) → last line of A
- то A(:, end) → last column of A

A(:,2)

A(2,3)

$$A = \begin{bmatrix} a_{11} & a_{12} & a_{13} & a_{14} & a_{15} \\ a_{21} & a_{22} & a_{23} & a_{24} & a_{25} \\ a_{31} & a_{32} & a_{33} & a_{34} & a_{35} \\ a_{41} & a_{42} & a_{43} & a_{44} & a_{45} \end{bmatrix}$$

A(1:3,1)

A(1:3,3:5)

$$A = \begin{bmatrix} a_{11} & a_{12} & a_{13} & a_{14} & a_{15} \\ a_{21} & a_{22} & a_{23} & a_{24} & a_{25} \\ a_{31} & a_{32} & a_{33} & a_{34} & a_{35} \\ a_{41} & a_{42} & a_{43} & a_{44} & a_{45} \end{bmatrix}$$

A(4,:)

$$A=\begin{bmatrix} 1 & 2 & 3 & 4 \\ 5 & 6 & 7 & 8 \\ 9 & 10 & 11 & 12 \\ 13 & 14 & 15 & 16 \end{bmatrix}$$

είναι ο εξής:

```
>> u=1:16


u =
  Columns 1 through 13
     1     2     3     4     5     6     7     8     9    10
11    12    13
  Columns 14 through 16
    14    15    16

>> A=zeros(4);

>> A(:)=u

A =
     1     5     9    13
     2     6    10    14
     3     7    11    15
     4     8    12    16

>> A=A'

A =
     1     2     3     4
     5     6     7     8
     9    10    11    12
    13    14    15    16
```

Element by element operations

Function of a vector or a matrix!

sin(u)

or

exp(A)

Element by element operations:

u.^2

1./u

A.^3

u.*v

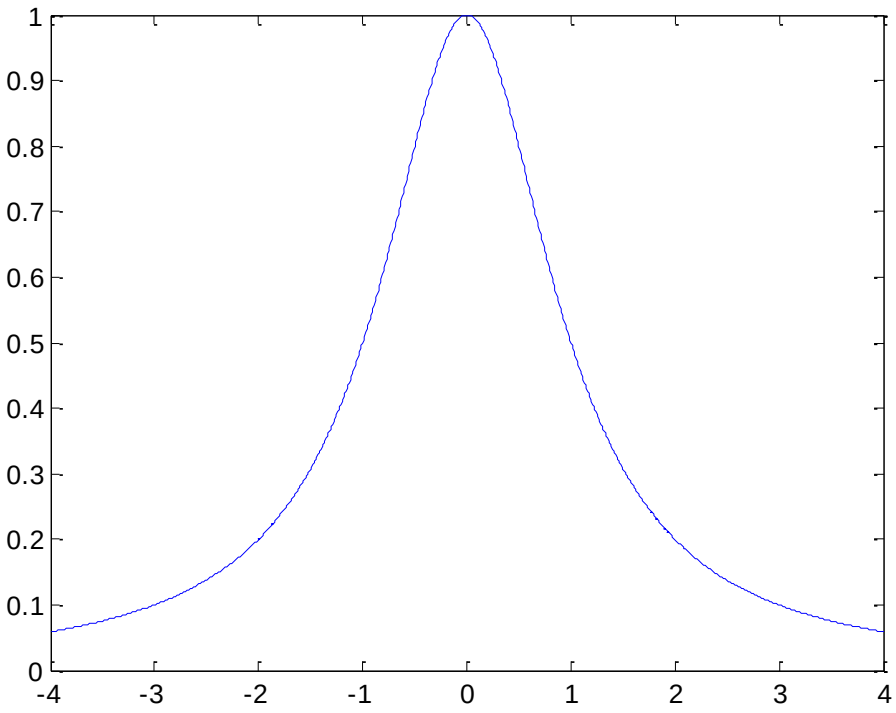
A.*B

C=2.^A

Example

$$f(x) = \frac{1}{x^2+1}$$

```
>> x=-4:0.01:4;
>> y=1./ ( x.^2+1);
>> plot(x,y)
```



See also: linspace

Functions for vectors

Συνάρτηση	Ερμηνεία
max	μέγιστο στοιχείο διανύσματος
min	ελάχιστο στοιχείο διανύσματος
length	μήκος διανύσματος
sort	ταξινόμηση σε αύξουσα σειρά
sum	άθροισμα στοιχείων
prod	γινόμενο στοιχείων
norm	νόρμα διανύσματος
median	διάμεσος
mean	μέση τιμή
std	τυπική απόκλιση

Functions for matrices

Function	
max min diag triu tril size length norm det trace rank inv rref eig poly cond	

MATRIX CONCATENATION

```
>> A=rand(2); B=rand(2); C=rand(2); D=rand(2);
>> [A B C]
ans =
    0.8147    0.1270    0.6324    0.2785    0.9575    0.1576
    0.9058    0.9134    0.0975    0.5469    0.9649    0.9706
>> [A; B; C]
ans =
    0.8147    0.1270
    0.9058    0.9134
    0.6324    0.2785
    0.0975    0.5469
    0.9575    0.1576
    0.9649    0.9706
>> [A B; C D]
ans =
    0.8147    0.1270    0.6324    0.2785
    0.9058    0.9134    0.0975    0.5469
    0.9575    0.1576    0.9572    0.8003
    0.9649    0.9706    0.4854    0.1419
```

See also: repmat and cat

Assigning values to submatrices

```
A(1:3,1:4)=0

A(3,:)= exp(1)

A(:,3:4)=pi

A(:,end)=1
```

Comment

```
A'        Conjugate transpose of A

A.'       Transpose of A

A.''      Conjugate of A
```

Example

```
>> A=[ 1+i 2-3i
4+2i  i]
A =
   1.0000 + 1.0000i   2.0000 - 3.0000i
   4.0000 + 2.0000i   0.0000 + 1.0000i
>> A'
ans =
   1.0000 - 1.0000i   4.0000 - 2.0000i
   2.0000 + 3.0000i   0.0000 - 1.0000i
>> A.'
ans =
   1.0000 + 1.0000i   4.0000 + 2.0000i
   2.0000 - 3.0000i   0.0000 + 1.0000i
>> A.''
ans =
   1.0000 - 1.0000i   2.0000 + 3.0000i
   4.0000 - 2.0000i   0.0000 - 1.0000i
>>
```

Comment

MATLAB increases the dimensions of a matrix when necessary.

```
>> A=ones(3)
A =
     1     1     1
     1     1     1
     1     1     1
>> A(5,6)=3
A =
     1     1     1     0     0     0
     1     1     1     0     0     0
     1     1     1     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     3
```

Other possibilities

`A(:,k)=[]`	Delete column k
`A(k,:))=[]`	Delete line k
`A(k:m,:)=[]`	Delete lines k to m
`A(:,k:m)=[]`	Delete columns k to m

Example

```
>> A=eye(6); A(:,3:4)=[]
A =
     1     0     0     0
     0     1     0     0
     0     0     0     0
     0     0     0     0
     0     0     1     0
     0     0     0     1
>> A=[eye(2) zeros(2); zeros(2,4); zeros(2) eye(2)]
A =
     1     0     0     0
     0     1     0     0
     0     0     0     0
     0     0     0     0
     0     0     1     0
     0     0     0     1
>> A=zeros(6,4); A(1:2,1:2)=eye(2); A(5:6,3:4)=eye(2)
A =
     1     0     0     0
     0     1     0     0
     0     0     0     0
     0     0     0     0
     0     0     1     0
     0     0     0     1
>>
```

Thank you!!