Lab II of MA2213

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1 Matrix functions

1.1 Functions for Vector

Suppose that

$$v = \begin{pmatrix} v_1 & v_2 & \cdots & v_n \end{pmatrix} \tag{1}$$

is a row vector in $\mathbb{R}^n$ or $\mathbb{C}^n$. We have the following functions for v.

command	meaning
sum(v)	$\sum_i v_i$
norm(v,1)	$\|v\|_1 = \sum_i \|v(i)\|$
norm(v,2)	same as norm(v), $\|v\|_2 = \sqrt{\sum_i v(i)^2}$
norm(v,inf)	$\max_i \|v(i)\|$
diag(v)	Create a diagonal matrix $$\begin{pmatrix} v_1 & 0 & \cdots & 0 \\ 0 & v_2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & v_n \end{pmatrix}$$
max(v)	$\max_i v_i$
$[m,k]$ = max(v)	$m = \max_i v(i)$, k is the first index such that $v_i = m$

Try the above functions with

```
v = [2,3,4,5,4,3,2,1];
```

1.2 Diagonal and triangular part of matrices

Suppose A is a $m \times n$ matrix

$$A = \begin{pmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{pmatrix}. \tag{2}$$

And we say that the element a_{ij} is on the k-th diagonal of A if j – i = k. For example the $1-th$ diagonal matrix of A is

$$A = \begin{pmatrix} 0 & a_{12} & 0 & \cdots & 0 \\ 0 & 0 & a_{23} & \cdots & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & 0 & \cdots & a_{n-1,n} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & 0 & \cdots & 0 \end{pmatrix}. \tag{3}$$

We have the following functions for A:

cmd	meaning
diag(A)	a column vector consisting of the diagonal elements of A
diag(A,k)	a column vector consisting of the elements from the k-th diagonal of A
tril(A)	matrix obtained from A by resetting all the elements of A above the diagonal to 0 (lower triangular)
triu(A)	matrix obtained from A by resetting all the elements of A below the diagonal to 0 (upper triangular)
tril(A,k)	matrix obtained from A by resetting all the elements of A above the k-th diagonal to 0
triu(A,k)	matrix obtained from A by resetting all the elements of A below the k-th diagonal to 0

For more information on MATLAB built-in matrix functions, type the command

```
> help matlab\matfun
```

2 Linear equation

Suppose A is a $n \times n$ invertible matrix, b is a n dimensional column vector. To solve

$$Ax = b \tag{4}$$

, we can use the command

```
inv(A)*b
```

or

```
A\b
```

Another way to solve the linear system is by the LU decomposition. The command

```
[L,U,P] = lu(A)
```

where $PA = LU$, L is a lower triangular matrix with a unit diagonal, U is a upper triangular matrix and P is a permutation matrix.

```
[M,N] = lu(A)
```

where M is a permuted lower triangular matrix and N is a upper triangular matrix such that $A = M * N$. In fact $M = PL$ and $N = U$.

```
Y = lu(A)
```

returns matrix Y that contains the strictly lower triangular L, i.e., without its unit diagonal, and the upper triangular U as submatrices. That is, if [L,U,P] = lu(A), then Y = U+L-eye(n). The permutation matrix P is not returned.

See Ref. https://www.mathworks.com/help/matlab/ref/lu.html

3 Input

```
x =input('the message for prompting'))
```

This command will first prompt the message on command window and then assign the value you input to the variable x. The value input could be of any type, for example the double, char, string, vector and so on.

4 Plotting

4.1 ezplot

```
ezplot('sin(x)')
```

will plot the graph of $\sin(x)$ over the domain $[-2\pi, 2\pi]$. The general usage of "ezplot" is

command	meaning
ezplot(f)	plots a symbolic expression, equation string, or function handle f over the default domain: $-2\pi \leqslant x \leqslant 2\pi$. For example "ezplot('cos(x)')", ezplot(@x cos(x))
ezplot(f,[min,max])	plots f over the specified range
ezplot(f,[xmin,xmax,ymin,ymax])	plots f over the specified ranges $xmin \leqslant x \leqslant xmax, ymin \leqslant y \leqslant ymax$.
ezplot(x,y)	plots the parametrically defined planar curve x = x(t) and y = y(t) over the default range $0 \leqslant t \leqslant 2\pi$. For example "ezplot('sin(t)','cos(t)')"
ezplot(x,y,[tmin,tmax])	plots x = x(t) and y = y(t) over the specified range $tmin \leqslant t \leqslant tmax$.

Try the following examples. plot the symbolic expression

```
syms t
x = t*sin(5*t);
y = t*cos(5*t);
ezplot(x, y)
```

Plot equation

```
syms x y
ezplot(x^2 == y^4)
```

Plot two variate symbolic function

```
syms x y
f(x, y) = sin(x + y)*sin(x*y);
ezplot(f);
```

Note that use the symbolic expression, you need the toolbox symbolic installed in matlab. See Ref. https://www.mathworks.com/help/symbolic/ezplot.html

4.2 Change the range displayed

```
axis([xmin,xmax,ymin,ymax])
```

displays the curve in the range: $xim \leqslant x \leqslant xmax$, $ymin \leqslant y \leqslant ymax$. If the limits set exceed the original range of the curve, it will display the white space. i.e., it differs with the limits set in ezplot(f,[xmin,xmax,ymin,ymax]). The axis command only changes the displayed range without evaluating the functions. See the difference

```
ezplot('sin(x)',[-8,-4,-1,1]);
```

```
ezplot('sin(x)');
axis([-8,-4,-1,1]);
```

4.3 Plot

Basic usage

```
plot(x,y)
```

plot the graph of $y = f(x)$, where x, y are two vectors of same length. For example, plot the graph of sin(x) among $[0, \pi]$

```
x = 0:0.01:pi;
y = sin(x);
plot(x,y);
```

4.4 Colors, Markers, and Line Styles

Basic usage

```
plot(x,y,'-.ro')
```

where “-.” is a line style,”r” is the color and “o” is one of the marker styles. We can change these settings specifically.

Specifier	line style
’-’	Solid line (default)
’–’	Dashed line
’:’	Dotted line
’-.’	Dash-dot line

Table 1: Line Style Specifiers

Specifier	Marker Type
’+’	Plus sign
’o’	Circle
’*’	Asterisk
’.’	Point
’x’	Cross
’square’ or ’s’	Square
’diamond’ or ’d’	Diamond
’^’	Upward-pointing triangle
’v’	Downward-pointing triangle
’>’	Right-pointing triangle
’<’	Left-pointing triangle
’pentagram’ or ’p’	Five-pointed star (pentagram)
’hexagram’ or ’h’	Six-pointed star (hexagram)

Table 2: marker style

Specifier	color
r	Red
g	Green
b	Blue
c	Cyan
m	Magenta
y	Yellow
k	Black
w	White

If the style are not specified, the matlab will automatically choose the line color with solid lines, no markers. We can also choose the line color with other colors for example

```
x = 0:0.1:2;
plot(x,sin(x),'color',[0.1,0.3,0.5])
```

where [0.1,0.3,0.5] is a color specification with RGB percentages. For example [0,0,0] stands for black color. See that following example

```
x = 0:0.1:2;
plot(x,sin(x),'+')
```

which will not show the line, only markers appear.

4.5 Multiple Graphs in a Figure

4.5.1 Using hold on command

First way to day multiple curves in the same figure window can be done with the hold on command. For example

```
ezplot('sin(x)',[-1,1]);
hold on
x = -1:0.1:1;
plot(x,cos(x));
```

4.5.2 Plot $(y_1, x_1, y_2, x_2, ...)$

The basic usage is

```
x1 = 0:0.1:2;
x2 = 0:0.2:3;
y1 = sin(x);
y2 = x2.^3;
plot(x1,y1,x2,y2);
```

where (x1,y1) and (x2,y2) are two curves. We also can change the specifiers of the graph.

```
x1 = 0:0.1:2;
x2 = 0:0.2:3;
y1 = sin(x);
y2 = x2.^3;
plot(x1,y1,'r--',x2,y2,'c:+');
```

Generally we have the syntax**plot(x1,y1,x2,y2,...,xn,yn)**

If the data on x-axis of each curve is same, we can put them y data together

```
x=0:0.1:1;
y1 = sin(x);
y2 = cos(x);
y3 = x.^3;
y4 = 1./(x+1);
plot(x,[y1;y2;y3;y4])
```

Or “plot(x,A)”, which will plot each row against x.

If there no “x” data. Then the default x-data would be the number of points. That is, plot(y) equals plot(1:length(y),y).

4.6 labels and legends

We can add the x-labels, y-labels and legend by

```
xlabel('x');
ylabel('y');
legend('first curve','second curve','third curve');
```

4.7 Save figures

Use the command to save as eps file

```
print -deps junk.eps
```

We can change it to another type

```
print -dpdf junk.pdf
print -djpeg junk.jpeg
print -dpng junk.png
```

See the site for more file format:https://www.mathworks.com/help/matlab/ref/print.html