08-Array Functions

text: Chapter 3.4-3.7

ECEGR 101
Engineering Problem Solving with Matlab
Professor Henry Louie

Overview

- Vectorization
- Array Functions

Using Matrices in Built-In Functions

The function operation is performed separately on each element of the matrix.

```
>> x = [2 4 8 16 32 64 128 256]
x =
    2    4    8   16   32   64  128  256
>>
>> y = log2(x)
y =
    1    2    3    4    5    6    7    8
```

vectorization

```
>> u = [-9 9 0]
u =
   -9    9    0
>>
>> a = abs(u)
a =
    9    9    0
```

```
>> x = [1:6; 7:12]
x =
    1    2    3    4    5    6
    7    8    9   10   11   12
>>
>> y = (sin(x)).^2 + (cos(x)).^2
y =
   1.0000   1.0000   1.0000   1.0000   1.0000   1.0000
   1.0000   1.0000   1.0000   1.0000   1.0000   1.0000
```

Exercise

A mortgage loan of amount L is obtained to buy a house. The interest rate r is 15% (0.15). The fixed monthly payment P which will pay off the loan exactly over N years is given by the formula

$$P = \frac{rL(1 + r/12)^{12N}}{12\left[(1 + r/12)^{12N} - 1\right]}.$$

Exercise

a) Write MATLAB commands to compute and print P if N=20 years, and the loan is for $50,000. You should get $658.39.

b) It's interesting to see how the payment P changes with the period N over which you pay the loan. Generate a vector with 10 different values of N and compute the corresponding payment values.

c) Now go back to having N fixed at 20 years, and examine the effect of different interest rates. Again, generate a vector with 10 different interest rates and compute the corresponding payment values.

Exercise

d) It is useful to be able to work out how the period of a loan repayment changes if you increase or decrease your monthly payment P. The formula for the number of years N to repay the loan is given by

$$N = \frac{\ln\left(\frac{P}{P - rL/12}\right)}{12\ln(1 + r/12)}$$

How long will it take to pay off the loan of $50,000 at $800 a month if the interest remains at 15%? (Answer 10.2 years).

Exercise

a) Write MATLAB commands to compute and print P if N = 20 years, and the loan is for $50,000. You should get $658.39. Use the command "format bank" to display your results.

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```
>> N = 20;
>> L = 50000;
>> r = 0.15;
>> P = (r*L*(1+r/12)^(12*N))/(12*((1+r/12)^(12*N)-1))
P =
      658.39
```

Exercise

b) It's interesting to see how the payment P changes with the period N over which you pay the loan. Generate a vector with 10 different values of N and compute the corresponding payment values.

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```
>> N = 5:5:50;
>>
>> P = (r*L*(1+r/12).^(12*N))./(12*((1+r/12).^(12*N)-
   1))
P =
  Columns 1 through 7
    1189.50      806.67      699.79      658.39
    640.42      632.22      628.41
  Columns 8 through 10
     626.61      625.76      625.36
```

Exercise

c) Now go back to having N fixed at 20 years, and examine the effect of different interest rates. Again, generate a vector with 10 different interest rates and compute the corresponding payment values.

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```
>> r = 0.05 : 0.02 : 0.23;
>> P =
   (r*L.*(1+r/12).^(12*N))./(12*((1+r/12).^(12*N)-1))
P =
  Columns 1 through 7
       329.98       387.65       449.86       516.09
    585.79       658.39       733.40
  Columns 8 through 10
       810.34       888.82       968.50
```

Exercise

$$N = \frac{\ln\left(\frac{P}{P - rL/12}\right)}{12\ln(1 + r/12)}$$

d) How long will it take to pay off the loan of $50,000 at $800 a month if the interest remains at 15%? (Answer 10.2 years).

Exercise

$$N = \frac{\ln\left(\frac{P}{P - rL/12}\right)}{12\ln(1 + r/12)}$$

d) How long will it take to pay off the loan of $50,000 at $800 a month if the interest remains at 15%? (Answer 10.2 years).

```
>> P = 800;
>> r = 0.15;
>> L = 50000;
>>
>> N = (log(P/(P-r*L/12)))/(12*log(1+r/12))
N =
       10.20
```

Built-In Matrix Functions

- mean(x) returns the mean value of the vector x.
- C = max(x) returns the maximum value of the vector x.
- [d,n] = max(x) returns the maximum value of a vector x in d and its position in n.
- sum(x) returns the sum of all elements in vector x.
- See your textbook for more examples.

Built-In Matrix Functions

```
>> x = [1 9 -7 3 8 -2 -10 3]
x =
    1    9   -7    3    8   -2  -10    3
>>
>> [m,i] = max(x)
m =
    9
i =
    2
```

```
>> x = 1:8
x =
    1    2    3    4    5    6    7    8
>>
>> y = sum(x)
y =
   36
```

```
>> x = [1:6; 7:12]
x =
    1    2    3    4    5    6
    7    8    9   10   11   12
>>
>> sum(x)
ans =
    8   10   12   14   16   18
>>
>> sum(sum(x))
ans =
   78
>>
>> sum(x(:))
ans =
   78
```

Stock Example

- In Canvas, download "stock.mat" under the "Data" folder
- Save .mat to your current working directory
- In the Matlab workspace type:
  - >>clear all; clc
  - >>load stock
  - >>whos

```
>> whos
  Name                Size              Bytes  Class     Attributes

  stock_close       252x1                2016  double
```

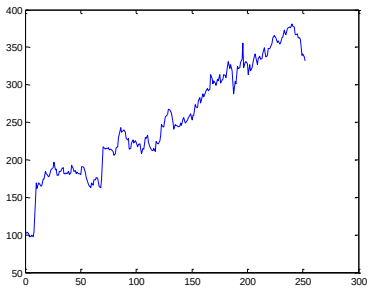

Stock Example

- The variable "stock_close" contains the closing price for real stock for each market day from 11 Jan. 2013 to 11 Jan. 2014, where the first element is the oldest price, and last element is most recent price
- Use Matlab to answer the following:
  - What was the maximum stock price?
    - Where in the vector did this occur?
  - What was the minimum stock price?
    - Where in the vector did this occur?
  - What is the average stock price?

Stock Example

```
>> [max_close,position]=max(stock_close)

max_close =

  380.5800


position =

   240

>> [min_close,position]=min(stock_close)

min_close =

   97.4800


position =

     4

>> mean(stock_close)

ans =

  253.8882
```

Type: plot(stock_close) to visualize the data



Exercise

What happens when we apply the built-in function max to a matrix (instead of a vector)?

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We will get a row vector containing the maximum element from each column.

Exercise

Write a single statement to find and display the sum of the successive even integers 2, 4, …, 200.

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Write a single statement to find and display the sum of the successive even integers 2, 4, …, 200.

```
>> sum(2:2:200)
ans =
    10100
```


Exercise

Given a matrix A, how can we find out the value and the position of its maximum?

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```
>> a = [4 3 4 3; 3 4 3 9; 1 5 7 2]
a =
    4    3    4    3
    3    4    3    9
    1    5    7    2
```

m = 9
xpos = 2
ypos = 4

Exercise

Given a matrix A, how can we find out the value and the position of its maximum?

```
>> a = [4 3 4 3; 3 4 3 9; 1 5 7 2]
a =
    4    3    4    3
    3    4    3    9
    1    5    7    2
```

m = 9
xpos = 2
ypos = 4

```
>> [m, xpos] = max(a)
m =
    4    5    7    9
xpos =
    1    3    3    2
```

```
>> [m, ypos] = max(m)
m =
    9
ypos =
    4
```

```
>> xpos=xpos(ypos)
xpos =
    2
```

Exercise

The following table shows the hourly wages, hours worked, and output (number of widgets produced) in one week for five widget makers.

	1	**2**	**3**	**4**	**5**
Hourly wage ($)	5	5.50	6.50	6	6.25
Hours worked	40	43	37	50	45
Output (widgets)	1000	1100	1000	1200	1100

Exercise

Use MATLAB to answer these questions:

a) How much did each worker earn in the week?

b) What is the total salary amount paid out?

c) How many widgets were made?

d) What is the average cost to produce one widget?

e) How many hours does it take to produce one widget on average?

f) Assuming that the output of each worker has the same quality, which worker is the most efficient? Which is the least efficient?

Exercise

```
>> hourly_wage = [5 5.50 6.50 6 6.25]
hourly_wage =
   5.0000    5.5000    6.5000    6.0000    6.2500
>>
>> hours_worked = [40 43 37 50 45]
hours_worked =
   40    43    37    50    45
>>
>> widgets_made = [1000 1100 1000 1200 1100]
widgets_made =
      1000       1100       1000       1200       1100
```


Exercise

a) How much did each worker earn in the week?

Exercise

a) How much did each worker earn in the week?

```
>> week_salary = hourly_wage .* hours_worked
week_salary =
236.5000  240.5000  300.0000  281.2500
```


Exercise

b) What is the total salary amount paid out?

Exercise

b) What is the total salary amount paid out?

```
>> total_salary = sum(week_salary)
total_salary =
  1.2583e+003
```


Exercise

c) How many widgets were made?

Exercise

c) How many widgets were made?

```
>> total_widgets = sum(widgets_made)
total_widgets =
        5400
```


Exercise

d) What is the average cost to produce one widget?

Exercise

d) What is the average cost to produce one widget?

```
>> ave_widgets_cost = total_salary/total_widgets
ave_widgets_cost =
    0.2330
```


Exercise

e) How many hours does it take to produce one widget on average?

Exercise

e) How many hours does it take to produce one widget on average?

```
>> total_hours = sum(hours_worked)
total_hours =
   215
>>
>> hours_per_widget = total_hours/total_widgets
hours_per_widget =
    0.0398
>>
>> hours_per_widget = 60*total_hours/total_widgets
hours_per_widget =
    2.3889
```


Exercise

f) Assuming that the output of each worker has the same quality, which worker is the most efficient? Which is the least efficient?

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```
>> efficiency = widgets_made ./ hours_worked
efficiency =
   25.0000   25.5814   27.0270   24.0000   24.4444
>> [max_efficiency, worker] = max(efficiency)
max_efficiency =
   27.0270
worker =
     3
>> [min_efficiency, worker] = min(efficiency)
min_efficiency =
    24
worker =
     4
```