MATLAB Tutorial

http://www.mathworks.co.kr/help/pdf_doc/matlab/getstart.pdf

Artificial Intelligence : Cognitive Agents

2014.04.26 Practice 2

Some tips

Entering Long Statements

If a statement does not fit on one line, use an ellipsis (three periods), **...**,
followed by Return or Enter to indicate that the statement continues on the next line.

```
>> result = 1 + 2 + 3 + 4 + 5 +
6 + 7 + 8 + 9 + 10
??? result = 1 + 2 + 3 + 4 + 5 +
                                |
Error: Expression or statement is incomplete or incorrect.
```

```
>> result = 1 + 2 + 3 + 4 + 5 + ...
6 + 7 + 8 + 9 + 10

result =

    55
```

Multiple Output from a Function

When there are multiple output arguments,
enclose them in square brackets
[maxA, location] = max(A)

```
>> [maxA location] = max([3 1 5 2 4])

maxA =

     5


location =

     3
```

Matrix&Array Operators

Matrix Operators

Expressions use familiar arithmetic operators and precedence rules.

+	Addition
-	Subtraction
*	Multiplication
/	Division
\	Left division
^	Power
'	Complex conjugate transpose
( )	Specify evaluation order

Array Operators

+	Addition
-	Subtraction
.*	Element-by-element multiplication
./	Element-by-element division
.\	Element-by-element left division
.^	Element-by-element power
.'	Unconjugated array transpose

Matrix Concatenation

Concatenation is the process of joining arrays to make larger ones.
In fact, you made your first array by concatenating its individual elements.
The pair of square brackets [] is the concatenation operator.

```
A =

     1     4     7    10
     2     5     8    11
     3     6     9    12
```

Horizontal concatenation

```
>> [A A]

ans =

     1     4     7    10     1     4     7    10
     2     5     8    11     2     5     8    11
     3     6     9    12     3     6     9    12
```

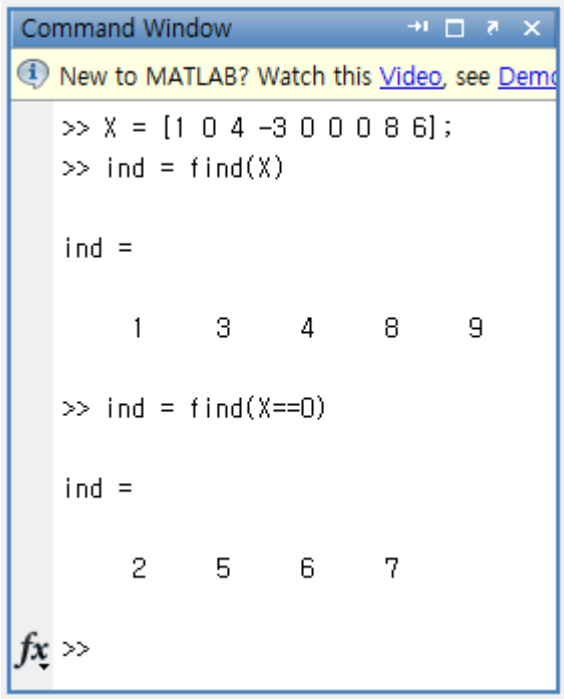
Vertical concatenation

```
>> [A; A]

ans =

     1     4     7    10
     2     5     8    11
     3     6     9    12
     1     4     7    10
     2     5     8    11
     3     6     9    12
```

Matrix functions – **find**

Find Indices and Values of Nonzero Elements

ind = find(X) locates all nonzero elements of array X, and returns the linear indices of those elements in vector ind.



Matrix functions – **size**

Array dimensions

d = size(X) returns the sizes of each dimension of array X in a vector, d

```
X =

    0.7655    0.1869    0.4456    0.7094
    0.7952    0.4898    0.6463    0.7547
```

d = size(X)

```
>> size(X)

ans =

     2     4
```

[m, n] = size(X)

```
>> [m, n] = size(X)

m =

     2


n =

     4
```

m = size(X, dim)

```
>> size(X, 1)

ans =

     2

>> size(X, 2)

ans =

     4
```

Matrix functions – **reshape**

Reshape array

- *B = reshape(A, m, n)* returns the m-by-n matrix B whose elements are taken column-wise from A.
- *B = reshape(A, m, [])* calculates the length of the dimension represented by []

```
A =

     1     4     7    10
     2     5     8    11
     3     6     9    12
```

B = reshape(A, m, n)

```
>> B = reshape(A, 2, 6)

B =

     1     3     5     7     9    11
     2     4     6     8    10    12
```

B = reshape(A, m, [])

```
>> B = reshape(A, 2, [])

B =

     1     3     5     7     9    11
     2     4     6     8    10    12
```

Other Matrix Functions

Identity Matrix

- *eye(m, n)* returns an *m*-by-*n* rectangular identity matrix
- *eye(n)* returns an *n*-by-*n* square identity matrix

Normalization

- *norm(X, p)* returns the *p*-norm of input *X*
- *norm(X)* returns the *2*-norm of input *X*. If X is a vector, this is equal to the Euclidean distance.

Diagonal of Matrix

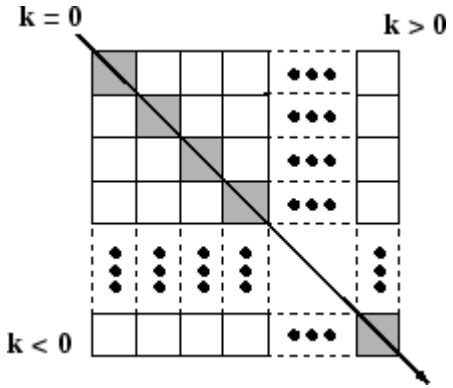
- *X = diag(v,k)* when v is a vector of n components, returns a square matrix X of order n+abs(k), with the elements of v on the kth diagonal. k = 0 represents the main diagonal, k > 0 above the main diagonal, and k < 0 below the main diagonal.

```
A =

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

```
>> diag(A)

ans =

     1
     6
    11
    16
```

```
>> diag(A, 1)

ans =

     2
     7
    12
```

```
>> diag(A, -1)

ans =

     5
    10
    15
```



Other Data Structures - **cell**

Cell arrays can contain data of varying types and sizes

- cell creation using *c = cell(m, n)*

```
>> C = cell(2, 2)

C =

    []    []
    []    []
```

- cell creation using *{}*

```
>> C = {1 'cell array'; [] {1, 2; 3, 4; 5, 6}}

C =

    [1]    'cell array'
     []      {3x2 cell}
```

- cell indexing c

```
>> C(1, 1)

ans =

    [1]
```

```
>> C(1, 2)

ans =

    'cell array'
```

- content indexing

```
>> C{1, 1}

ans =

     1
```

```
>> C{1, 2}

ans =

    cell array
```

Other Data Structures - **struct**

Structures are multi-dimensional MATLAB arrays with elements accessed by textual *field designators*.

- Structure creation *s = struct(filed1, value1, …, fileN, valyeN)*

```
>> S = struct('name', 'Imelda', 'score', 100, 'grade', 'A')

S =

     name: 'Imelda'
    score: 100
    grade: 'A'
```

```
>> S(2) = struct('name', 'Jane', 'score', 0, 'grade', 'F')

S =

1x2 struct array with fields:
    name
    score
    grade
```

- Access data in a struct array

```
>> sIname = S(1).name

sIname =

Imelda

>> names = {S.name}

names =

    'Imelda'    'Jane'
```

```
>> S(1).score

ans =

   100

>> scores = [S.score]

scores =

   100     0
```

Loops & Conditional Statements

Within a script, you can loop over sections of code and conditionally execute sections using the keywords for, while, if, and switch.

for & switch

```
for i=1:10
    switch i
        case 1
            disp('this is 1');
        case {2, 3}
            disp('this is 2~3');
        otherwise
            disp('this is 4~10');
    end
end
```

while & if

```
i = 1;
while i<=10
    if i==1
        disp('this is 1');
    elseif i==2 || i==3
        disp('this is 2~3');
    else
        disp('this is 4~10');
    end
    i = i+1;
end
```

Result:

```
this is 1
this is 2~3
this is 2~3
this is 4~10
this is 4~10
this is 4~10
this is 4~10
this is 4~10
this is 4~10
this is 4~10
```

Loading Data

Load Data

load (dataFile) or *load dataFile* Load variables from file into workspace

```
>> load('MNIST_Dataset.mat')
```

Name	Value
testingData	<1x1 struct>
trainingData	<1x1 struct>

Missing Data

- *NaN* (Not a Number) value is a normally used to represent missing data. *NaN* values allow variables with missing data to maintain their structure
- *isnan(c)* returns a logical vector the same size as c, with entries indicating the presence(1) or absence(0) of *NaN* values for each of the elements in the data.

```
>> isnan([1 1 NaN 2 NaN])

ans =

     0     0     1     0     1
```

Read&Display Image

Read Image from Graphics File

```
>> img = imread('img.jpg');
```

Name	Value	Min	Max
img	<513x684x3 uint8>	<Too many elements>	<Too many elements>

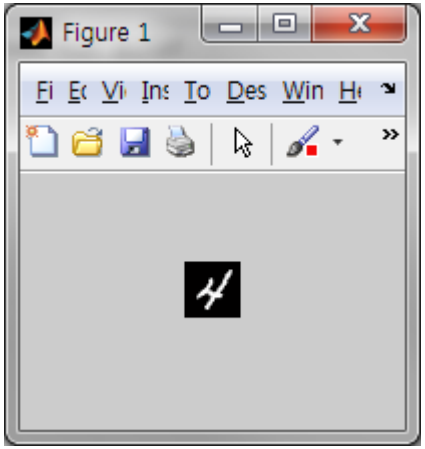
HEIGHT x WIDTH x RGB

Display Image

```
>> imshow(img)
```

Exercise:

Display 10th MNIST data using load, reshape, imshow, accessing structure



Loops vs. Matrix Multiplication

- **Don’t use FOR or WHILE so much**
- **Think whether it can be converted to Matrix Multiplication**

```
N = 1000;

A = rand(N,N);
B = rand(N,N);
C = zeros(N,N);
fprintf('C1: ');
tic;
for i = 1:N
    for j = 1:N
        for k = 1:N
            C(i,j) = C(i,j) + A(i,k) * B(k,j);
        end
    end
end
toc;
```

```
fprintf('C2: ');
tic;
C2 = A*B;
toc;
```

```
C1: Elapsed time is 79.169012 seconds.
C2: Elapsed time is 0.108808 seconds.
```

Loops vs. Matrix Multiplication

- **Don’t use FOR or WHILE so much**
- **Think whether it can be converted to Matrix Multiplication**

```
train_x = trainingData.Images(:,1:1000)';
train_c = trainingData.Labels(1:1000,:);
test_x = testingData.Images(:,1:100)';
test_c = testingData.Labels(1:100,:);
classifier_c = -ones(100,1);

tic;
nearest_idx = zeros(size(test_x,1),1);
for j = 1:size(test_x,1)
    distance = zeros(N,1);
    for i = 1:size(train_x,1)
        for k = 1:size(train_x,2)
            distance(i) = distance(i) + (train_x(i,k)-test_x(j,k))*(train_x(i,k)-test_x(j,k));
        end
    end
    [min_val nearest_idx(j)] = min(distance);
    classifier_c(j) = train_c(nearest_idx(j));
end
toc;
accuracy = sum((test_c - classifier_c) == 0) / size(test_c,1)
```

Loops vs. Matrix Multiplication

- **Don’t use FOR or WHILE so much**
- **Think whether it can be converted to Matrix Multiplication**

```
train_x = trainingData.Images(:,1:1000)';
train_c = trainingData.Labels(1:1000,:);
test_x = testingData.Images(:,1:100)';
test_c = testingData.Labels(1:100,:);
classifier_c = -ones(100,1);

tic;
nearest_idx = zeros(size(test_x,1),1);
for j = 1:size(test_x,1)
   distance = zeros(size(train_x,1),1);
   for i = 1:size(train_x,1)
      for k = 1:size(train_x,2)
         distance(i) = distance(i) + (train_x(i,k)-test_x(j,k))*(train_x(i,k)-test_x(j,k));
      end
   end
   [min_val nearest_idx(j)] = min(distance);
   classifier_c(j) = train_c(nearest_idx(j));
end
toc;
accuracy = sum((test_c - classifier_c) == 0) / size(test_c,1)
```