Introduction to Matlab

CSE555 Introduction to Pattern Recognition

Spring 2011 recitation

Introduction to Matlab

- Matlab stands for “Matrix Laboratory”. It was originally designed for solving linear algebra problems using matrices.

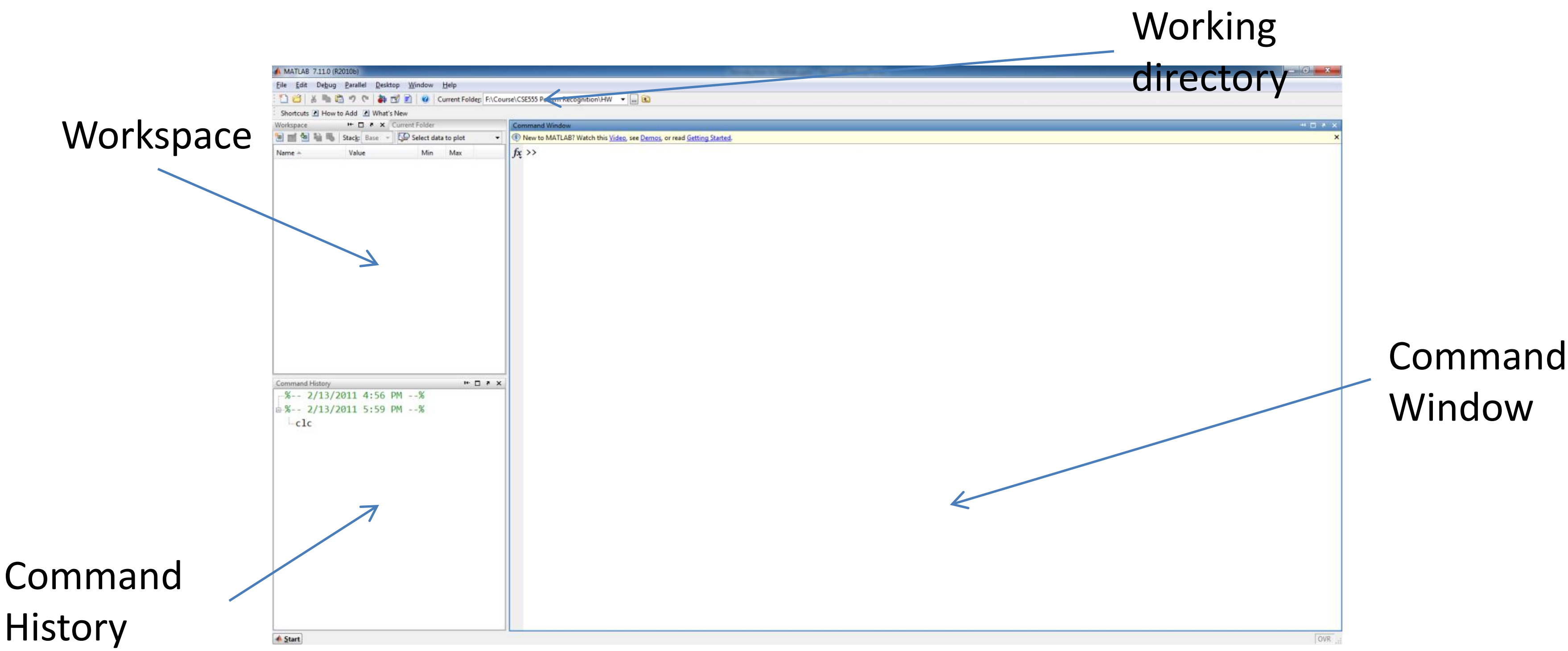
- Matlab is also a programming language that is widely used as a platform for developing Image Processing, Machine Learning programs.

Introduction to Matlab

Matlab is a very useful prototyping language

- A lot of libraries/toolboxes and tons of functions
- Easy to visualize data
- Quick prototype development
- Can cooperate with C/C++
- Can be slow, especially with bad programming practice

Introduction to Matlab



Introduction to Matlab

- Variables
  - Does not require to be declared before use
  - Have not been defined previously (otherwise will overload the variable)
  - Variable name must start with a letter (e.g. _ind, 1st are not valid variable names)
  - Variable names are case sensitive (e.g. Test and test are two different variables)

Introduction to Matlab

- Operators
  - Assignment: x = y
  - Addition/subtraction: x + y, x – y
  - Multiplication (scalar or matrix): x * y
  - Multiplication (by element): x .* y
  - Division (scalar or matrix): x / y
  - Division (by element): x ./ y
  - Power: x ^ y, x .^ y

Introduction to Matlab

```
>> x

x =

     1     2     3     4     5

>> y

y =

     1     2
     3     4

>> x = y

x =

     1     2
     3     4
```

Introduction to Matlab

```
x =

     1     2
     3     4

>> x + 1

ans =

     2     3
     4     5

>> x + x

ans =

     2     4
     6     8
```

```
y =

     8     1     6
     3     5     7
     4     9     2

>> x + y
??? Error using ==> plus
Matrix dimensions must agree.
```

Introduction to Matlab

```
x =

     1     2
     3     4
```

```
>> x*x

ans =

     7    10
    15    22
```

```
>> x.*x

ans =

     1     4
     9    16
```

```
>> x^2

ans =

     7    10
    15    22
```

```
>> x.^x

ans =

     1     4
    27   256
```

```
>> x*2

ans =

     2     4
     6     8
```

```
>> x.*2

ans =

     2     4
     6     8
```

```
>> x.^2

ans =

     1     4
     9    16
```

Introduction to Matlab

- Keep in mind that all variables in Matlab are treated as matrices.
- When not using element by element operation such as “.*”, “./” the operations are really the same as matrix operations.

Introduction to Matlab

- Define a matrix

```
>> x = [1,2,3;4,5,6]

x =

     1     2     3
     4     5     6

>> x = [1,2,3;4,5,6];
```

- Apostrophe operator (‘) makes the transpose operation

```
>> x'

ans =

     1     4
     2     5
     3     6
```

Introduction to Matlab

- Matrix operations
  - matrix(r, c) will return the element that at row r and column c

```
x =

     1     2     3
     4     5     6

>> x(1,3)

ans =

     3
```

Introduction to Matlab

- Matrix operations
  - matrix(r1 : rstep : r2, c1 : cstep : c2) will return a portion of the matrix, where r1, r2 specifies the beginning and ending row of the matrix, and c1, c2 specifies the beginning and ending column of the matrix, rstep and cstep denotes the step size to increment from r1 to r2 and c1 to c2 respectively. r1:1:r2 is equivalent to r1:r2.
  - If we want whole row or column, we could use ‘:’ to replace the corresponding position.

Introduction to Matlab

```
x =

    92    99     1     8    15    67    74    51    58    40
    98    80     7    14    16    73    55    57    64    41
     4    81    88    20    22    54    56    63    70    47
    85    87    19    21     3    60    62    69    71    28
    86    93    25     2     9    61    68    75    52    34
    17    24    76    83    90    42    49    26    33    65
    23     5    82    89    91    48    30    32    39    66
    79     6    13    95    97    29    31    38    45    72
    10    12    94    96    78    35    37    44    46    53
    11    18   100    77    84    36    43    50    27    59
```

```
>> x (2 : 5, 1 : 3)

ans =

    98    80     7
     4    81    88
    85    87    19
    86    93    25
```

```
>> x(1:2:7, 1:2:5)

ans =

    92     1    15
     4    88    22
    86    25     9
    23    82    91
```

Introduction to Matlab

```
>> x(:,1)

ans =

    92
    98
     4
    85
    86
    17
    23
    79
    10
    11

>> x(1,:)

ans =

    92    99     1     8    15    67    74    51    58    40
```

Introduction to Matlab

i : j	Denotes the number from i to j, i.e. [i, i+1, i+2, … , j], and is empty if j < i
i : s : j	Denotes the number from i to j take on step value s, i.e. [i, i+s, i+2s, … , j
A(i, :)	The ith row of A
A(:, i)	The ith column of A
A(i:s:j, :)	The same as A(i, :), A(i+s, :), …, A(j, :)
A(vecA, vecB)	The matrix that contain the rows specified in vector vecA, and columns specified in vector vecB
A(:)	Convert all the elements in A to a single column vector.

Introduction to Matlab

- Matrix operation
  - If we want to access to the last row/column of a matrix, we can use keyword ‘end’ in the corresponding position.
  - Matrix can also be concatenated using ‘,’ or ‘;’

    z = [x, y]; or z = [x; y]

    The corresponding dimensions must fit while we concatenate the matrices/vectors.

Introduction to Matlab

- Some matrix functions
  - x = ones(number of rows, number of columns)

    Constructs a full matrix with ones.
  - x = zeros(number of rows, number of columns)

    Constructs a full matrix with zeros.
  - x = diag(y)

    Constructs a diagonal matrix with y be the diagonal elements. If y is a matrix, x will be the diagonal elements in matrix y.

Introduction to Matlab

- Some matrix functions
  - x = mean(y) calculate the mean value for y. If y is a vector, x is a scalar value, if y is a matrix, each row of y is treated as observations, and the corresponding mean is calculated.

```
x =

     1     2     3
     4     5     6

>> mean(x)

ans =

    2.5000    3.5000    4.5000
```

Introduction to Matlab

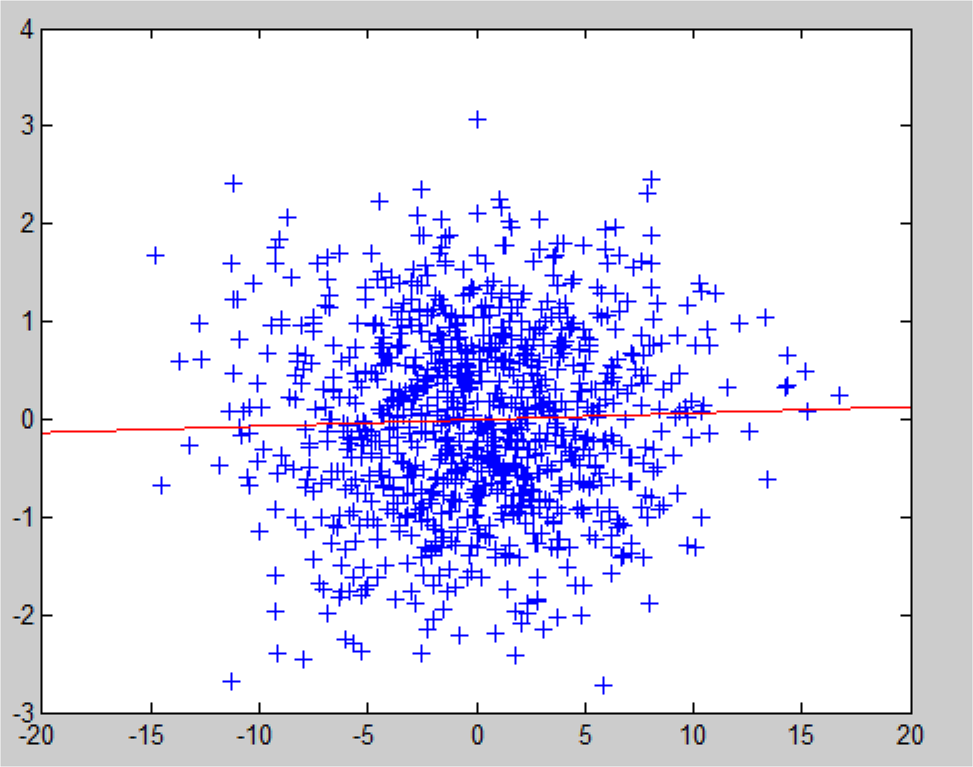
- Some matrix functions
  - y = cov(x) calculate the covariance matrix of x
  - [y, ind] = sort(x, option) sort vector x according to the option, can either be ascending order or descending order.
  - y = inv(x) calculate the inverse of matrix x
  - y = det(x) calculate the determinant of matrix x
  - [vec, val] = eig(x) calculate the eigenvalue and eigenvector of matrix x

Introduction to Matlab

- Plotting figures
  - plot(x, y) plot y as a function of x, x and y must have the same number of elements.
  - plot(x) is equivalent to plot(1:length(x), x)
  - use ‘hold on’ and ‘hold off’ to plot multiple functions in one figure.
- Displaying images
  - imshow(f) f is the image

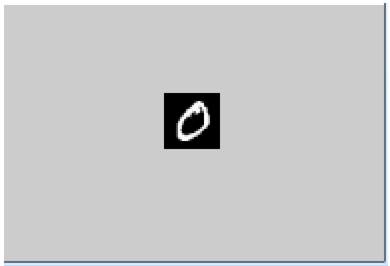
Introduction to Matlab

```
>> x = randn(1, 1000)*5;
>> y = randn(1, 1000);
>> m=mean([x',y']);
>> plot(x, y, '+');
>> hold on;
>> x1 = -20:0.001:20;
>> x2 = a(2,1)/a(1,1)*(x1-m(1))+m(2);
>> plot(x1, x2,'r');
>> hold off;
```



Introduction to Matlab

```
>> f = imread('./homework2-data/train0/00000.pgm');
>> imshow(f);
```



Introduction to Matlab

- Matlab programming
  - Expressions
  - Flow Controls
    - Condition
    - Iteration
  - Scripts
  - Functions

Introduction to Matlab

- Relational operators
  - Less than <
  - Less than or equal <=
  - Greater than >
  - Greater than or equal >=
  - Equal to ==
  - Not equal to ~=
- Logical operators
  - Not ~, and &, or |

Introduction to Matlab

- Conditional structures

```
if condition
    expressions
elseif condition (optional)
    expressions
else
    expressions
end
```

Introduction to Matlab

- Iterations

for variable = expression

expressions

end

while condition

expressions

end

```
for i=1:2:10
    do whatever
end

while i < 10
    do whatever
end
```

Introduction to Matlab

- ".m" files
  - Plain text files containing Matlab programs (functions/scripts). Can be called from command line by typing the filename, or from other M-files.
  - **Scripts** are like main() function in C/C++, except they do not return values and do not take input arguments.
  - **Functions** take input arguments and return values.

Introduction to Matlab

- Functions
  - File name must be the same as the function name.
  - Can contain many sub-functions in one function file.

```
'function_name.m'
function [out1, out2, …, outN] = function_name(arg1, arg2, …, argN)
…….
```

Introduction to Matlab

- Good programming practice in Matlab
  - Do not use loops unless there is no other way to do it, loops are **slow** in Matlab. Most functions in Matlab take matrix/vector input and runs very fast (look at the help documents).
  - Always prefer matrix operations.
  - Allocate spaces for matrix/vectors before assign them values.

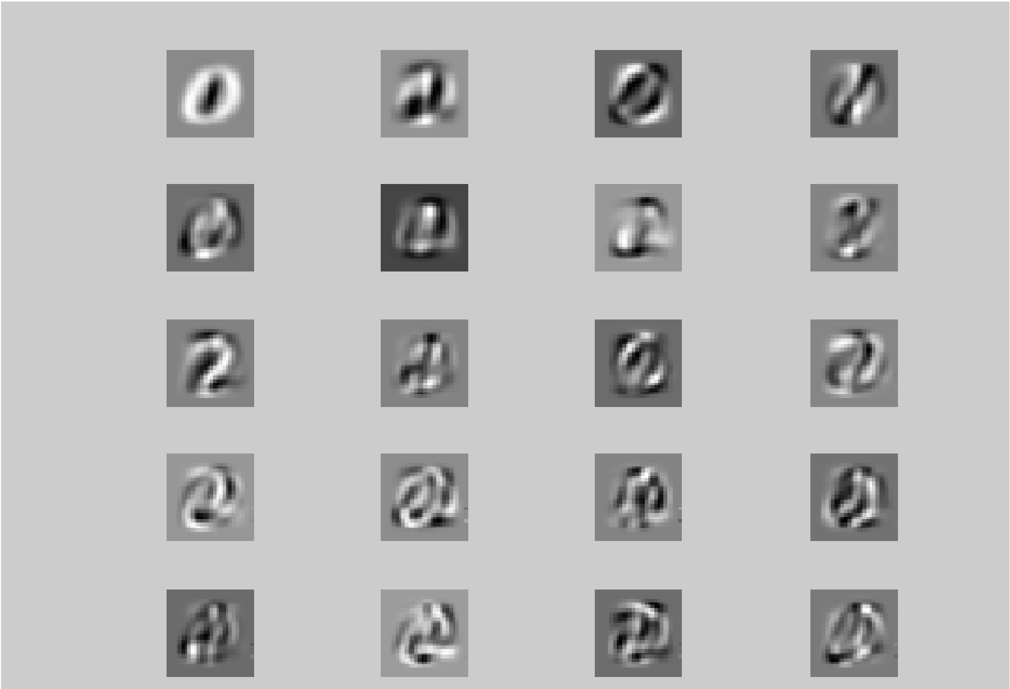
Hints on HW2-4

- Load image
  - image = imread('image path');
  - imagepath = sprintf('path/%d.extension', number);
  - imagepath = ['path/', num2str(number), '.extension'];
  - double_image = im2double(image);
  - use function zeros/ones to allocate space for training and testing vectors

Hints on HW2-4

- Compute PCA
  - use function reshape(x, r, c) to convert image into vector form, and convert vector images to original size for displaying.
  - cov(x) function calculates the covariance matrix of x, each row of x should be an observation.
  - [evec, eval] = eig(x) function will calculate the eigenvalues and eigenvectors of x. Each column of evec will be a eigen vector, eval will be a diagonal matrix, we can use diag(eval) to convert it to a vector.
  - [val, idx] = sort(x, option) will sort vector x according to option, ‘descend’ or ‘ascend’.

Hints on HW2-4



```
>>  figure;
for i = 1 : 5
for j = 1 : 4
subplot(5, 4, i+(j-1)*5);imshow(reshape(pvec(:,i+(j-1)*5), 28, 28), []);
end
end
```

Hints on HW2-4

- Classification
  - If our data have M dimensions, and we have N samples, and we choose the top D vectors from PCA, then each M dimensional data point will have a D dimensional representation after applying PCA.
  - If we organize the original samples in a NxM matrix S, with each row contains an observation. Assume V is the eigenvector we got from PCA, to transform the data points it is simply an multiplication of two matrix S x V.

Hints on HW2-4

- Classification
  - To do classification we just need to find the nearest neighbors in the lower dimensional space.