MATLAB FOR PATTERN RECOGNITION

MIN 720 – Pattern Classification for Biomedical Applications

05/04/2011

How Much Do We Know?

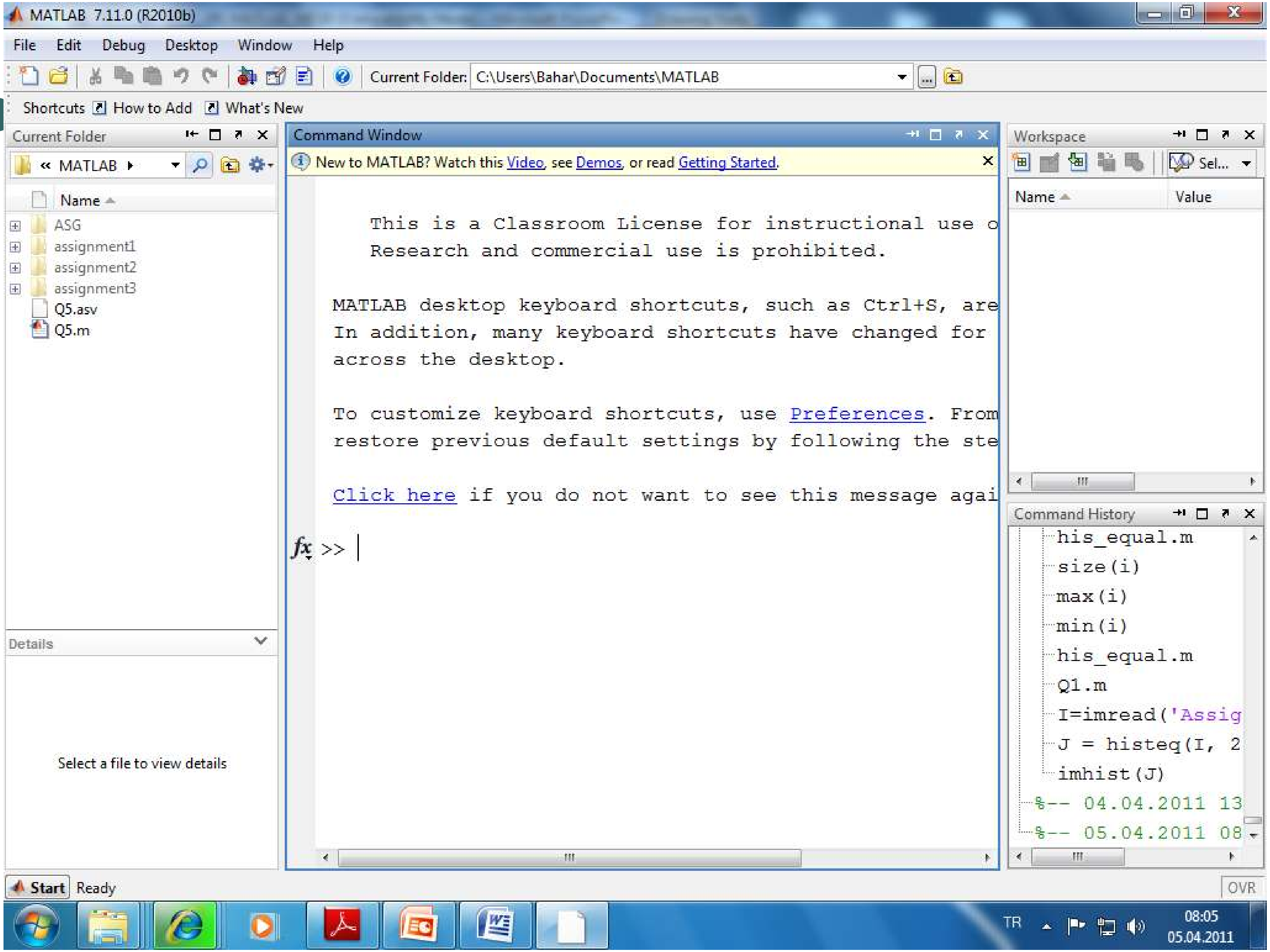
- Anybody who has never used MATLAB?

Outline

- An Introduction to MATLAB
- Generation of Random Data
- Basic Statistical Functions
- Parameter/Density Estimation Functions
- Classification/Clustering Functions
- MATLAB Toolboxes for Pattern Recognition

MATLAB Environment

- Workspace: Variables defined so far.
- Command History
- Command Window
- Editor
- Plot Window
- Current Directory: Start by setting the current directory to the directory that you are working. Generally, it is where your files are.
- Workspace Window


MATLAB 7.11.0 (R2010b)
File Edit Debug Desktop Window Help
Current Folder: C:\Users\Bahar\Documents\MATLAB
Shortcuts How to Add What's New
Current Folder
« MATLAB ›
Name
ASG
assignment1
assignment2
assignment3
Q5.asv
Q5.m
Details
Select a file to view details
Command Window
New to MATLAB? Watch this Video, see Demos, or read Getting Started.
This is a Classroom License for instructional use o
Research and commercial use is prohibited.
MATLAB desktop keyboard shortcuts, such as Ctrl+S, are
In addition, many keyboard shortcuts have changed for
across the desktop.
To customize keyboard shortcuts, use Preferences. From
restore previous default settings by following the ste
Click here if you do not want to see this message agai
fx >>
Workspace
Sel...
Name
Value
Command History
his_equal.m
size(i)
max(i)
min(i)
his_equal.m
Q1.m
I=imread('Assig
J = histeq(I, 2
imhist(J)
%-- 04.04.2011 13
%-- 05.04.2011 08
Start
Ready
OVR
TR
08:05
05.04.2011

LOOKFOR & HELP

- LOOKFOR: Type ‘lookfor smth’ to learn the name of functions that are related to ‘smth’.

- HELP: Type ‘help function_name’ to learn how that function works, its inputs and outputs.

Expressions

- Variables:
  - No need to make type declarations or dimension statements
  - When Matlab encounters a new variable name, it automatically creates the variable and allocates the appropriate amount of storage.

Example:

```
>> num_students = 25
```

Creates a 1-by-1 matrix named num_students and stores the value 25 in its single element

Expressions

- Cell:
  - A matrix which can store a separate variable (matrix with different dimensions, etc.) in each of its indices.
  - Useful for storing many matrices in a single structure in a compact manner.

Example:

```
a=cell(2,2);
a{1,1}=[2 4];
a{1,2}=[5 8; 8 9];
```

Expressions

- Structures:
  - Can store different attributes of an object in a single structure (like in Object Oriented Programming).

Example:

```
student.year = 3;
student.number=1556782;
```

Creates a structure and stores the declared attributes.

Functions

- Standard elemantary mathematical functions; abs, sqrt, exp, sin …
- For a list of elemantary mathematical functions type

  >> help elfun
- For a list of more advanced mathematical and matrix functions type

  >>help specfun

  >>help elmat
- Most of the functions are overloaded.

Vectors and Matrices

- **Scalar:** ‘5’, pi …
- **Vector:** Ordered list of numbers

  Example: to represent a point in three dimensional space

```
>>p1=[1 3 4]
p1 =  1  3  4
>>p2=[1;3;4]
p2 = 1
     3
     4
```

Accessing a Vector

- Access to the elements of vectors

```
>>p1(1)
 ans =
          1
```

Creating Matrices

- **Matrices:**

```
>> a = [ 1 2 2 1 ]
a = 1 2 2 1
>> b= [1; 2; 2; 1]
b=
   1
   2
   2
   1
>>c=zeros(1,2);
c= 0 0
>>d=ones(1,3);
d= 1 1 1
```

Creating Matrices from Vectors

- It is possible to create matrices from row or column vectors, as long as all of the vectors being used to create the matrix have the same number of elements.
- Examples…

Accessing a Matrix

- Accessing element of a matrix

```
>>a=[2 4; 5 8];
>>a(1,:)
2 4
>>a(:,2)
5
8
```

- Accessing subset of a matrix

```
>>b=[1 2 3 ; 4 5 6; 7 8 9];
>>b(2:3,2:3)
5 6
8 9
```

Matrix Operations

- Matrix operations like, (for matrices “x” and “y”)
  - Determinant of a matrix (det(x))
  - Inverse of a matrix (x^-1) or inv(x)
  - Transpose of a matrix (x’)
  - Element by element multiplication(x.*y), division(x./y)
  - Matrix multiplication(x*y), division(x/y), summation(x+y), subtraction(x-y)
  - … are defined in MATLAB.

Flow Control-IF

```
>> if a+b==5
        m=1;
   elseif a+b==3
        m=2;
   end
>>
```

Flow Control-Switch

```
>> switch (n)
    case 0
                    M=0
    case 1
                    M=1
    otherwise
                    M=2
    end
```

Loops

For/End

a = [0.8 0.1; 0.2 0.9 ; 0.4 0.6]

```
>> for i = 1:1:3
        x(i,:) = a(i,:).*i
   end
```

While/End

- a=3; ax=0
- while a==3
-     ax=ax+2
-     if ax>50
-         a=4
-     end
-     end
- Avoid using Loops in Matlab.

M-Files: Scripts And Functions

- **Scripts**: Do not accept input arguments or return output arguments. They operate on data in the workspace.

- **Functions:** can accept input arguments and return output arguments. Internal variables are local to the function.

Function Definition

- Name of the function and the file should be the same.

```
function[output1,output2]=example(input)
```

Graphical Representation

- Generally ‘plot’ is used for drawing graphics.

>>plot(x) ;

plots the columns of x versus their index.

Many options are provided for this

function. ‘stem’ can also be used.

- “imagesc” is used to display an image or visualize a 2D matrix.

figure

imagesc(A)

colormap(gray)

Read & Write Files

- Load, Save,Saveas
- Textread
- …
- There are many other functions for file operations. Check File I/O part in Mathwork's Help.

Generating Random Data

There are many functions for generating random samples from a desired distribution with the specified parameters.

- random('name',a,b,c,....) creates a matrix with the specified dimensions whose entries are samples drawn from the specified distribution.

```
>> x1 = random('unif',0,1,2,4)
    0.8003    0.4218    0.7922    0.6557
    0.1419    0.9157    0.9595    0.0357
```

Generating Random Data

- normrnd(mu,sigma,m,n) creates a mxn matrix whose entries are samples drawn from a normal distribution with specified parameters.

>> normrnd(50,10,2,5)

45.674	51.253	38.535	61.891	53.272
33.344	52.876	61.909	49.623	51.746

- exprnd(mu,m,n) creates a mxn matrix from an exponential distribution.

>>exprnd(30,2,3)

13.1593	12.4551	37.1646
6.0277	32.1909	32.2592

Generating Random Data

- mvnrnd(mu,cov,n) creates a nxd matrix whose indices are drawn from a d dimensional multivariate gaussian distribution.

```
>> mu=[5 10];
>> cov=[2 -1; -1 3];
>> mvnrnd(mu,cov,3)
   6.7734   10.0164
   2.7461   10.4947
   2.9622   12.1099
```

There are also functions for random data generation of other common distributions.

Likelihood Evaluation Functions

- They calculate likelihood for a specific distribution in a given point.
- normpdf(x,mu,sigma)

```
>> normpdf(4,5,1)
   0.2420
```

- exppdf(x,mu)

```
>>exppdf(10,20)
    0.0303
```

- (betapdf( ), mvnpdf( ), etc.)

Basic Statistical Functions

- Functions for calculating the descriptive statistics of distributions.
- mean(x) returns the mean value of a 1D matrix.

```
>>x=[2 8 4];
>> mean(x)
    4.6667
```

- Std(x) returns the standard deviation (with Bessel's correction(correction factor n/(n-1))

```
std(x)
    3.0551
```

Basic Statistical Functions

- var(x) returns the variance (with Bessel's correction)

```
>> var(x)
   9.3333
```

- median(x) returns the sample of the distribution which is in the middle rank when samples are ordered.

```
>>median(x)
    4
```

Basic Statistical Functions

- cov(x) returns the variance (with Bessel's correction)

```
>>x=[1 2 ;3 4];
>> cov(x)
     2    -1
    -1     3
```

- mean2(x) and std2(x) are functions for 2D case.

```
>>mean2(x)
    2.5000
>> std2(x)
    1.2910
```

Distance/Metric Functions

- mahal(y,x) returns the Mahalanobis distance of the data points(rows) of y to the distribution characterized by the samples(rows) of x.

```
>>x=[2 3; 4 7 ; 1 5];
>> y=[2 7];
>> mahal(y,x)
   2.3333
```

- pdist(x) returns the Euclidean distance between pairs of data(rows) points of x.

```
>> pdist(x)
   4.4721    2.2361    3.6056
```

Distance/Metric Functions

- pdist(x,distance) can be used to find the distance between pairs of data of x with the specified distance metric.

```
>> pdist(x,'cityblock')
   6    3    5
```

- norm(x) returns the norm of a matrix(or vector).

```
>>norm(x)
  10.0906
```

Parameter Estimation Functions

- normfit(x) returns the mean and standard deviation of the data that is assumed to be originated from normal distribution.

```
>> x=[3 2 6 4 7 3];
>>[mu_est,sig_est]=normfit(x)
mu_est =
   4.1667
sig_est =
   1.9408
```

Parameter Estimation Functions

- expfit(x) returns the mean of the data that is assumed to be originated from exponential distribution.

```
>>expfit(x)
 4.1667
```

- There are similar functions for other commonly used distributions. The confidence intervals(with adjustable confidence) may also be obtained for the estimates.

Parameter Estimation Functions

- mle(x,'distribution','dist') returns the maximum likelihood (ML) estimate of the parameters that is assumed to be originated from the specified distribution by 'dist'.

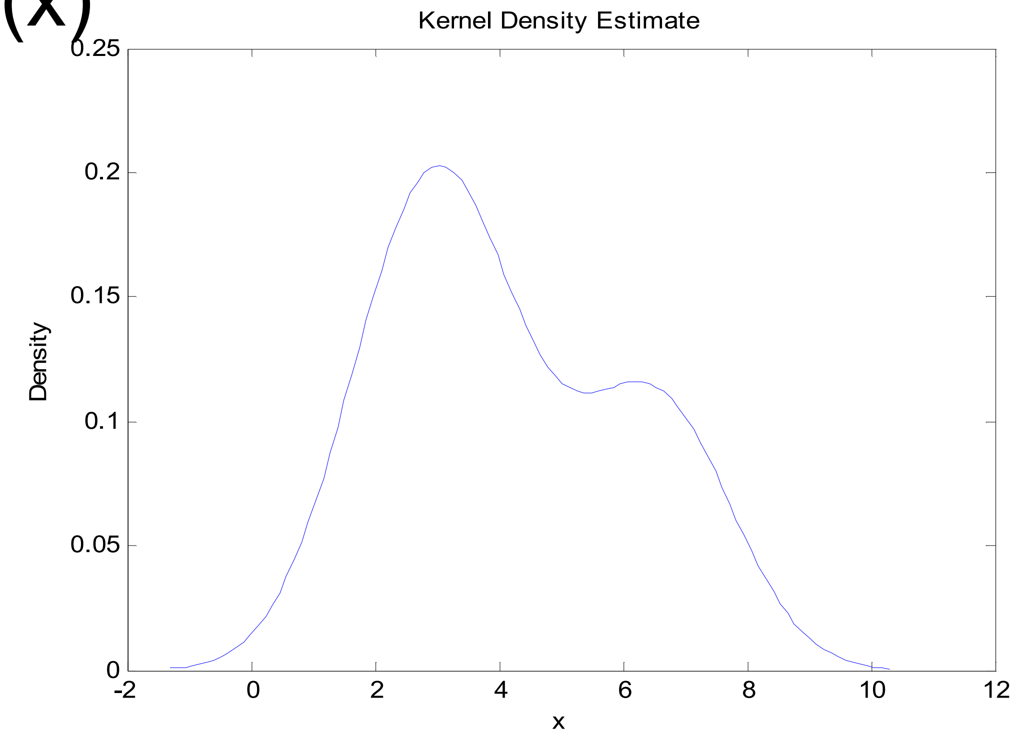
```
>>mle(x,'distribution','normal')
   4.1667    1.7717
>> mle(x,'distribution','gamma')
   5.6322    0.7398
```

When it is used as mle(x)(with no distribution specification), normal distribution is assumed.

Density Estimation Functions

- ksdensity(x) returns the computed density estimate using a kernel smoothing method.

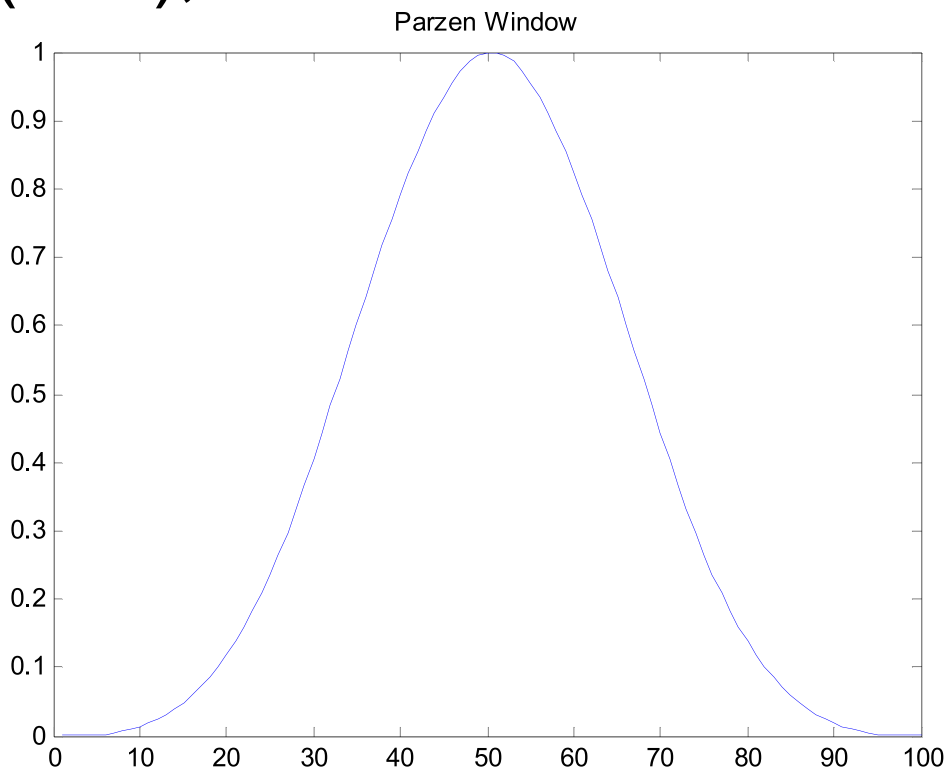
```
>> x=[3    2    6    4    7    3];
>> ksdensity(x)
```



Density Estimation Functions

- parzenwin(n) forms a parzen window having n elements.

```
>>x=parzenwin(100);
>> plot(x)
```



Classification/Clustering Functions

- knnclassify(sample, training, group) classifies each data of the sample matrix using nearest neighbor rule which is supervised by the training data and its labeling.

```
>> x=normrnd(10,3,5,1)
   13.2850
    4.3780
   11.2845
   12.6869
   12.1929
```

```
>> y=normrnd(13,3,5,1)
   11.8676
   12.1123
    8.5746
   12.2980
   13.3553
```

Classification/Clustering Functions

```
>> training=[x;y];
>> group=[ones(5,1); 2*ones(5,1)];
>> sample=normrnd(11,3,4,1)
   11.9444
   15.3305
    9.9471
   12.8697
>> knnclassify(sample, training, group)
    [2; 2;1;1]
```

Classification/Clustering Functions

- knnclassify(sample, training, group,k) classifies each data using k-nearest neighbor rule.

```
>>knnclassify(sample, training, group,3)
   [2;1;2;1]
```

Note that classification result changes.

- knnclassify(sample, training, group,k,distance) performs classification using the specified distance metric (default is euclidean distance.).

Classification/Clustering Functions

- kmeans(x,k) clusters the data into k classes using k means clustering algorithm.

>>kmeans(training,2)

2;2;1;2;2;1;1;1; 1; 2

- kmeans function can also be used with other distance metrics(kmeans(x,k,’distance’,’dist’).

>> kmeans(training,2,'distance','cityblock')

1;1;2;1;1; 2;2; 2; 2;1

Classification/Clustering Functions

- classify(sample,training,group) classifies the sample data into classes using the training dataset labeled with group. It performs discriminant analysis.

```
>> classify(sample,training,group)
   [2;2;1;2]
```

- The type of discriminant function to be used can be adjusted.

```
>> classify(sample,training,group,'quadratic')
   [2;1;2;2]
```

Classification/Clustering Functions

- The priors of the classes can be incorporated into classification.

```
>> prior=[0.1 0.9];
>>classify(sample,training,group,'quadratic',prior)
   [2;2;2;2]
>> prior=[0.9 0.1];
>> classify(sample,training,group,'quadratic',prior)
   [1;1;1;1]
```

- The choice of priors is critical.

Classification/Clustering Functions

- clusterdata(x,cutoff) clusters the data using a hierarchical cluster tree. cutoff is a parameter to adjust the number of clusters to be formed at the end (0<cutoff<2).

```
>> x=normrnd(20,2,5,1);
>> y=normrnd(30,2,5,1);
>> z=[x;y];
>> t=clusterdata(z,1)
   [4;4;2;1;1;3;3;3;3;3]
```

Classification/Clustering Functions

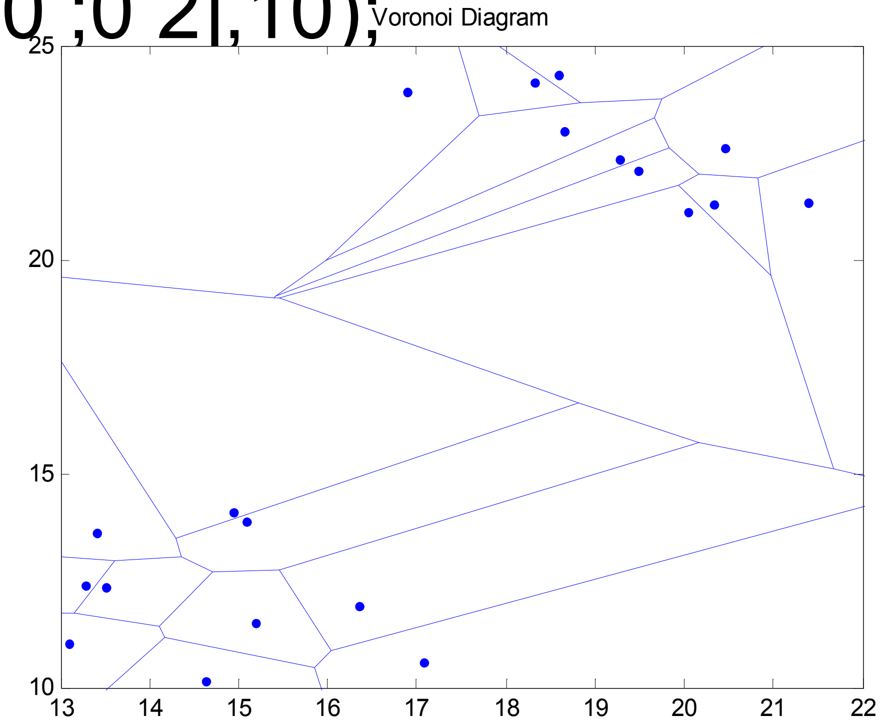
```
>> t=clusterdata(z,1.2)
    [1;1;1;1;1;1;1;1;1;1]
```

- The distance metric to be used can be changed and the maximum number of clusters to be formed can be specified.

Classification/Clustering Functions

- voronoi(x,y) forms the voronoi diagram for the datasets x and y.

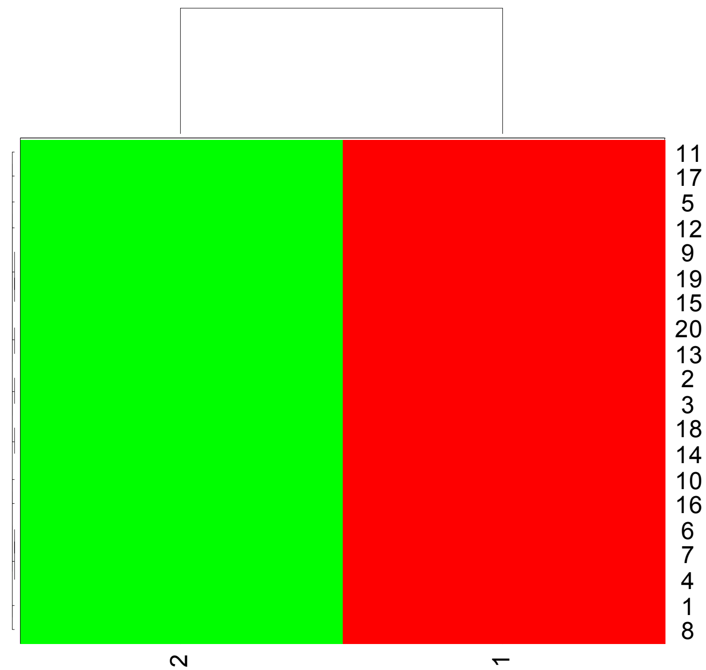
```
>> x=mvnrnd([20 ; 15],[2 0 ;0 2],10);
>> y=mvnrnd([23 ; 12],[2 0 ;0 2],10);
>> voronoi(x,y)
```



Classification/Clustering Functions

- clustergram(x) draws the dendogram of the dataset x. The similar and distant datasets are visualized.

```
>> z=[x;y];
>> clustergram(z)
```



Dimension Reduction Functions

- pcacov(v) performs Principal Component Analysis (PCA) using the covariance matrix and returns the coefficient matrix.

```
>> v=[1 0.4 -0.2; 0.4 1.3 0.2; -0.2 0.2 0.8];
>> pcacov(v)
  -0.5485    0.5811    0.6012
  -0.8330   -0.3171   -0.4534
  -0.0729   -0.7495    0.6580
```

Dimension Reduction Functions

- PCA can also be performed with princomp(x) directly from the data.

```
>>princomp(x)

   0.6668    0.7453
   0.7453   -0.6668
```

MATLAB Toolboxes

- A Toolbox is a collection of m-files developed to perform computation on a particular domain.

Ex:Animation toolbox(Developing scientific animations)

- Some toolboxes are present inside MATLAB but some are not embedded. They are available on the Internet.

MATLAB Toolboxes

- Neural Networks Toolbox:

Includes tools for designing, implementing, visualizing and simulating neural networks.

- Statistics Toolbox:

Provides tools for modeling and analyzing data, simulating systems, developing statistical algorithms, learning and teaching statistics.

MATLAB Toolboxes

- PRTools Toolbox:

Includes algorithms for data generation, training classifiers, features selection, density estimation, feature extraction, cluster analysis.

- Statistical Pattern Recognition Toolbox:

It provides users with procedures for discriminant functions, feature extraction, density estimation, support vector machines, visualization, regression, etc..

MATLAB Toolboxes

- PRTools Toolbox:

Includes algorithms for data generation, training classifiers, features selection, density estimation, feature extraction, cluster analysis.

- Statistical Pattern Recognition Toolbox:

It provides users with procedures for discriminant functions, feature extraction, density estimation, support vector machines, visualization, regression, etc..

MATLAB Toolboxes

- Fuzzy Logic Toolbox
- Classification Toolbox
- Clustering Toolbox
- ClusterPack Toolbox
- GHSOM Toolbox
- HMM Toolbox
- HMMBOX Toolbox
- LPSVM Toolbox
- NSVM Toolbox

MATLAB Toolboxes

- PCNN Toolbox
- SDH Toolbox
- SOM Toolbox
- SSVM Toolbox
- SVM Toolbox
- SVM Classifier Toolbox
- Bioinformatics Toolbox

END

Thank you for listening.

Any Questions or
Comments ??