MATLAB for Image Processing

Outline

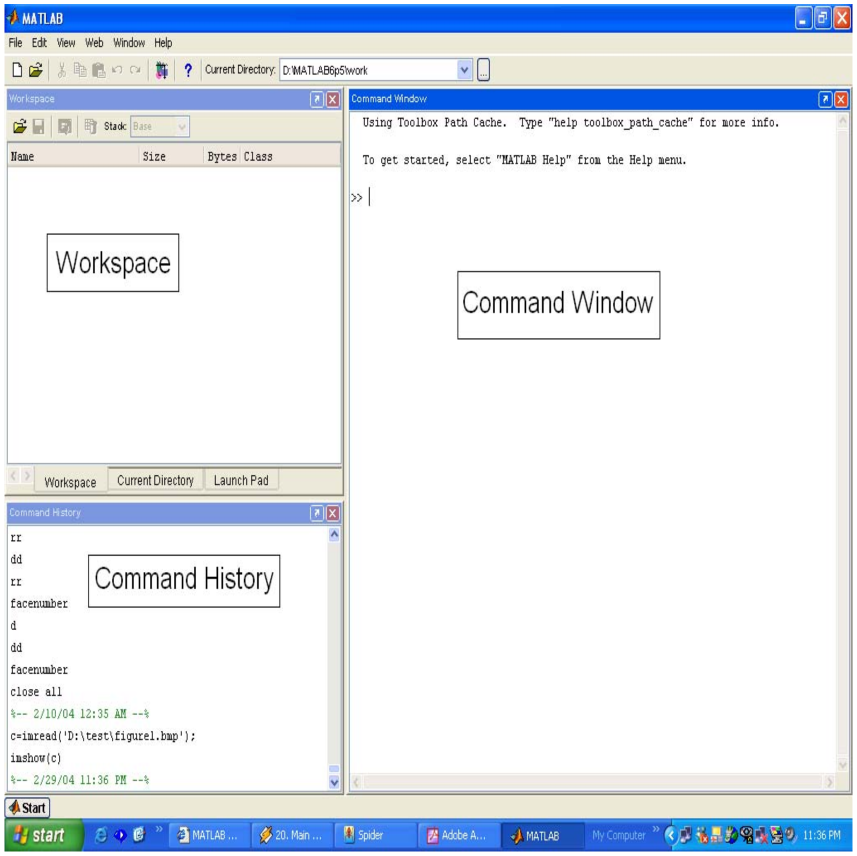
- **Introduction to MATLAB**
  - **Basics & Examples**

- Image Processing with MATLAB
  - Basics & Examples

What is MATLAB?

- MATLAB = Matrix Laboratory
- “MATLAB is a high-level language and interactive environment that enables you to perform computationally intensive tasks faster than with traditional programming languages such as C, C++ and Fortran.” (www.mathworks.com)
- MATLAB is an interactive, interpreted language that is designed for fast numerical matrix calculations

The MATLAB Environment

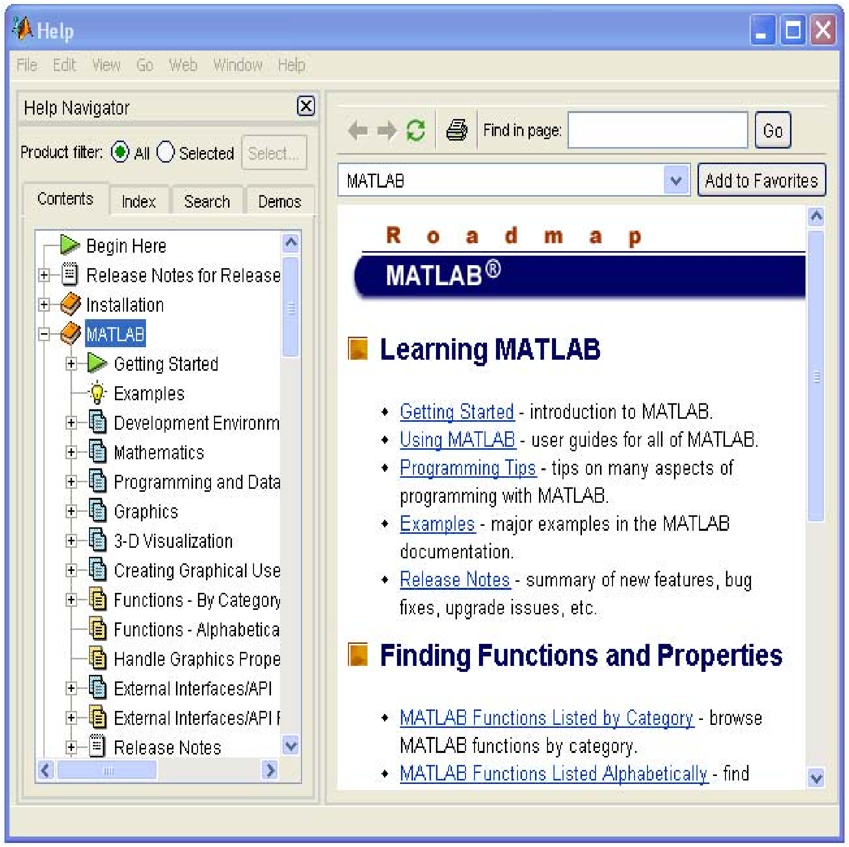


```
Using Toolbox Path Cache.  Type "help toolbox_path_cache" for more info.

To get started, select "MATLAB Help" from the Help menu.

>> |
```

```
rr
dd
rr
facenumber
d
dd
facenumber
close all
%-- 2/10/04 12:35 AM --%
c=imread('D:\test\figure1.bmp');
imshow(c)
%-- 2/29/04 11:36 PM --%
```

- MATLAB window components:
  - Workspace
    - > Displays all the defined variables
  - Command Window
    - > To execute commands in the MATLAB environment
  - Command History
    - > Displays record of the commands used
  - File Editor Window
    - > Define your functions

MATLAB Help



Learning MATLAB

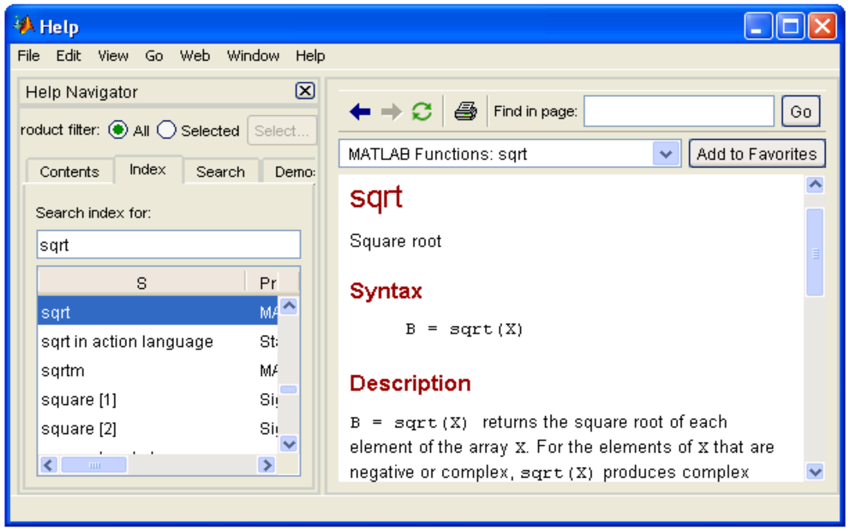
- Getting Started - introduction to MATLAB.
- Using MATLAB - user guides for all of MATLAB.
- Programming Tips - tips on many aspects of programming with MATLAB.
- Examples - major examples in the MATLAB documentation.
- Release Notes - summary of new features, bug fixes, upgrade issues, etc.

Finding Functions and Properties

- MATLAB Functions Listed by Category - browse MATLAB functions by category.
- MATLAB Functions Listed Alphabetically - find

- MATLAB Help is an extremely powerful assistance to learning MATLAB
- Help not only contains the theoretical background, but also shows demos for implementation
- MATLAB Help can be opened by using the HELP pull-down menu

MATLAB Help (cont.)



sqrt

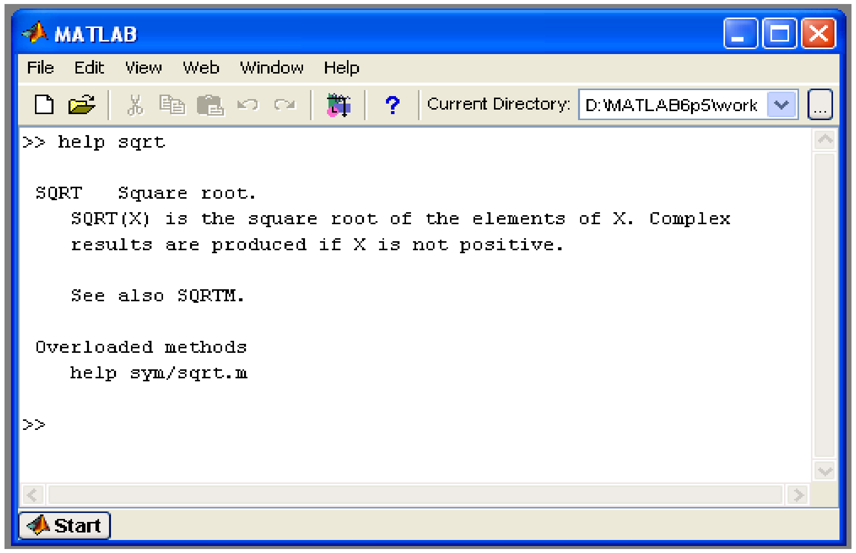
Square root

Syntax

```
B = sqrt(X)
```

Description

`B = sqrt(X)` returns the square root of each element of the array `X`. For the elements of `X` that are negative or complex, `sqrt(X)` produces complex


MATLAB
File Edit View Web Window Help
Current Directory: D:\MATLAB6p5\work
Start

```
>> help sqrt

 SQRT   Square root.
    SQRT(X) is the square root of the elements of X. Complex
    results are produced if X is not positive.

    See also SQRTM.

 Overloaded methods
    help sym/sqrt.m

>>
```

- Any command description can be found by typing the command in the search field
- As shown above, the command to take square root (`sqrt`) is searched
- We can also utilize MATLAB Help from the command window as shown

More about the Workspace

- `who`, `whos` – current variables in the workspace
- `save` – save workspace variables to *.mat file
- `load` – load variables from *.mat file
- `clear` – clear workspace variables

Matrices in MATLAB

- Matrix is the main MATLAB data type
- How to build a matrix?
  - `A=[1 2 3; 4 5 6; 7 8 9];`
  - Creates matrix A of size 3 x 3
- Special matrices:
  - `zeros(n,m), ones(n,m), eye(n,m), rand(), randn()`
- `Numbers are always double (64 bits) unless you specify a different data type`

Basic Operations on Matrices

- All operators in MATLAB are defined on matrices: `+, -, *, /, ^, sqrt, sin, cos`, etc.
- Element-wise operators defined with a preceding dot: `.*, ./, .^`
- `size(A)` – size vector
- `sum(A)` – columns sums vector
- `sum(sum(A))` – sum of all the elements

Variable Name in Matlab

- Variable naming rules

  - must be unique in the first 63 characters

  - must begin with a letter

  - may not contain blank spaces or other types of punctuation

  - may contain any combination of letters, digits, and underscores

  - are case-sensitive

  - should not use Matlab keyword

- Pre-defined variable names
  - pi

Logical Operators

- `==,  <,  >,` (not equal) ~=, (not) ~
- `find('condition')` – Returns indexes of A's elements that satisfy the condition

Logical Operators (cont.)

- Example:

```
>>A=[7 3 5; 6 2 1], Idx=find(A<4)
  A=
     7 3 5
     6 2 1
  Idx=
     3
     4
     6
```

Flow Control

- MATLAB has five flow control constructs:
  - `if` statement
  - `switch` statement
  - `for` loop
  - `while` loop
  - `break` statement

if

- IF statement condition
  - The general form of the IF statement is

```
IF expression
   statements
ELSEIF expression
   statements
ELSE
   statements
END
```

- CODE

switch

- SWITCH – Switch among several cases based on expression
- The general form of SWITCH statement is:

```
SWITCH switch_expr
    CASE case_expr,
        statement, …, statement
    CASE {case_expr1, case_expr2, case_expr3, …}
        statement, …, statement
        …
    OTHERWISE
        statement, …, statement
END
```

switch (cont.)

- Note:
  - Only the statements between the matching `CASE` and the next `CASE`, `OTHERWISE`, or `END` are executed
  - Unlike C, the `SWITCH` statement does not fall through (so `BREAK`s are unnecessary)

- CODE

for

- FOR repeats statements a specific number of times

- The general form of a FOR statement is:

```
FOR variable=expr
   statements
END
```

  - CODE

while

- WHILE repeats statements an indefinite number of times
- The general form of a WHILE statement is:

```
WHILE expression
   statements
END
```

- CODE

Scripts and Functions

- There are two kinds of M-files:
  - Scripts, which do not accept input arguments or return output arguments. They operate on data in the workspace
  - Functions, which can accept input arguments and return output arguments. Internal variables are local to the function

Functions in MATLAB (cont.)

- Example:
  - A file called STAT.M:

```
function [mean, stdev]=stat(x)
%STAT Interesting statistics.
n=length(x);
mean=sum(x)/n;
stdev=sqrt(sum((x-mean).^2)/n);
```

  - Defines a new function called STAT that calculates the mean and standard deviation of a vector. Function name and file name should be the SAME!
  - CODE

Visualization and Graphics

- `plot(x,y),plot(x,sin(x))` – plot 1D function
- `figure, figure(k)` – open a new figure
- `hold on, hold off` – refreshing
- `axis([xmin xmax ymin ymax])` – change axes
- `title('figure titile')` – add title to figure
- `mesh(x_ax,y_ax,z_mat)` – view surface
- `contour(z_mat)` – view z as topo map
- `subplot(3,1,2)` – locate several plots in figure

Saving your Work

- `save mysession`

  % creates mysession.mat with all variables
- `save mysession a b`

  % save only variables a and b
- `clear all`

  % clear all variables
- `clear a b`

  % clear variables a and b
- `load mysession`

  % load session

Outline

- Introduction to MATLAB
  - Basics & Examples
- **Image Processing with MATLAB**
  - **Basics & Examples**

What is the Image Processing Toolbox?

- The Image Processing Toolbox is a collection of functions that extend the capabilities of the MATLAB’s numeric computing environment. The toolbox supports a wide range of image processing operations, including:
  - Geometric operations
  - Neighborhood and block operations
  - Linear filtering and filter design
  - Transforms
  - Image analysis and enhancement
  - Binary image operations
  - Region of interest operations

Images in MATLAB

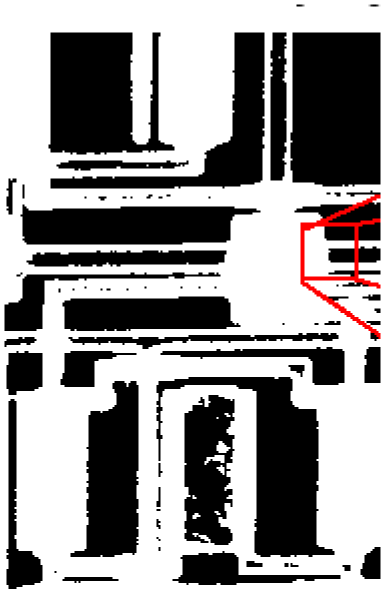
- MATLAB can import/export several image formats:
  - BMP (Microsoft Windows Bitmap)
  - GIF (Graphics Interchange Files)
  - HDF (Hierarchical Data Format)
  - JPEG (Joint Photographic Experts Group)
  - PCX (Paintbrush)
  - PNG (Portable Network Graphics)
  - TIFF (Tagged Image File Format)
  - XWD (X Window Dump)
  - raw-data and other types of image data

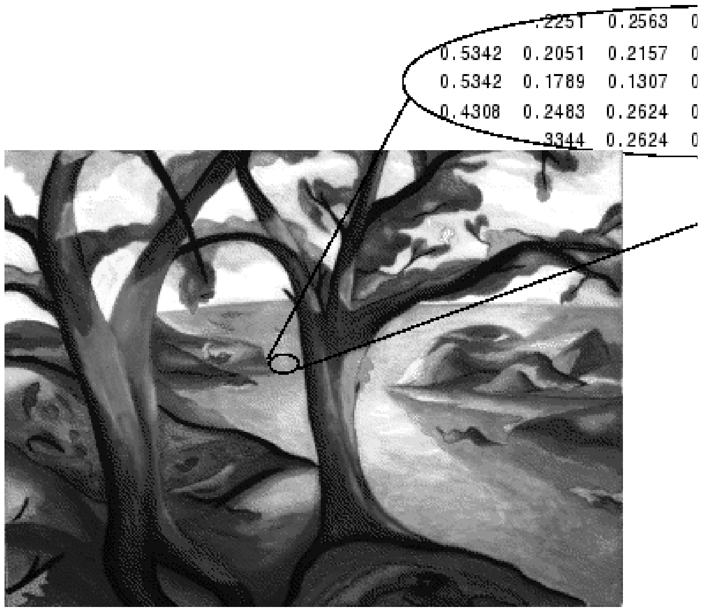
- **Typically switch images to double to perform any processing and convert back to unsigned integer**

- Data types in MATLAB
  - Double (64-bit double-precision floating point)
  - Single (32-bit single-precision floating point)
  - Int32 (32-bit signed integer)
  - Int16 (16-bit signed integer)
  - Int8 (8-bit signed integer)
  - Uint32 (32-bit unsigned integer)
  - Uint16 (16-bit unsigned integer)
  - Uint8 (8-bit unsigned integer)

Images in MATLAB

- Binary images : {0,1}
- Intensity images : [0,1] or `uint8`, `double` etc.
- RGB images : m × n × 3
- Multidimensional images: m × n × p (p is the number of layers)





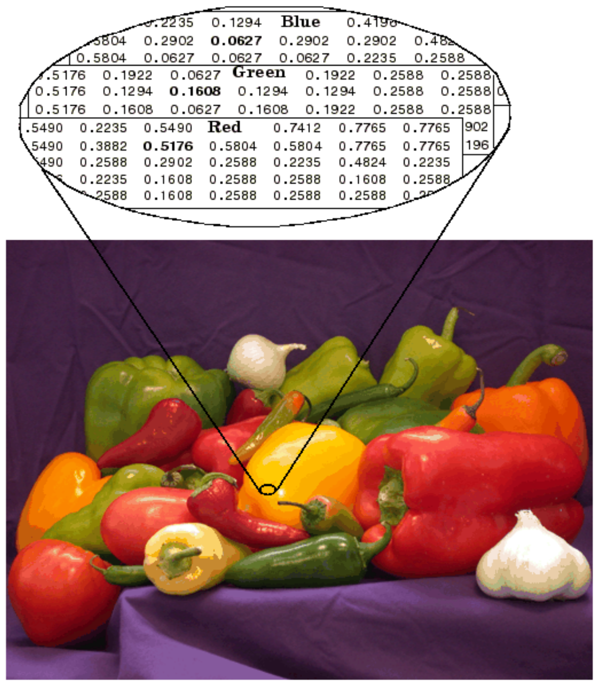


Image Import and Export

- Read and write images in Matlab

```
img = imread('apple.jpg');
dim = size(img);
figure;
imshow(img);
imwrite(img, 'output.bmp', 'bmp');
```

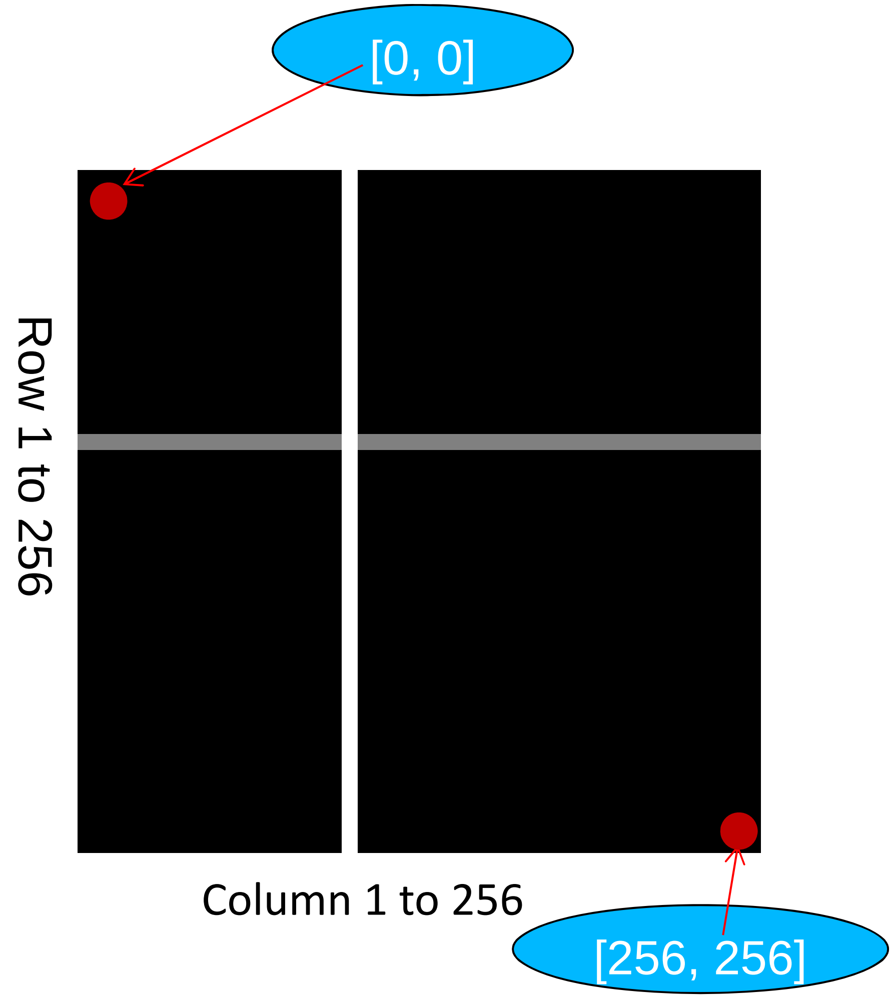
- Alternatives to `imshow`

```
imagesc(I)
imtool(I)
image(I)
```

Images and Matrices

How to build a matrix (or image)?
Intensity Image:

```
row = 256;
col = 256;
img = zeros(row, col);
img(100:105, :) = 0.5;
img(:, 100:105) = 1;
figure;
imshow(img);
```



Images and Matrices

Binary Image:

```
row = 256;
col = 256;
img = rand(row,
col);
img = round(img);
figure;
imshow(img);
size(im)
```

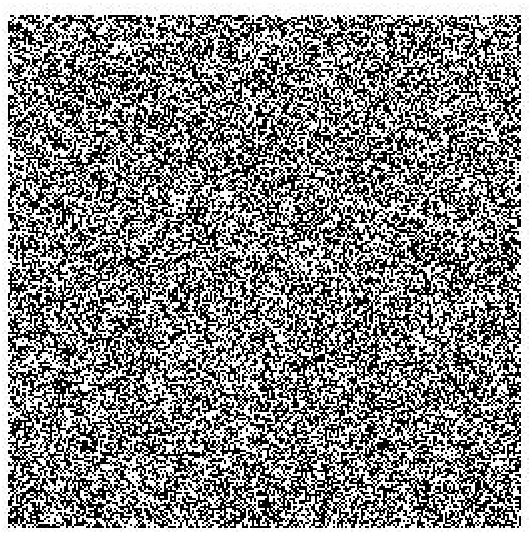


Image Display

- `image` - create and display image object
- `imagesc` - scale and display as image
- `imshow` - display image

Performance Issues

- The idea: MATLAB is
  - very <u>fast on vector and matrix operations</u>
  - Correspondingly <u>slow with loops</u>

- Try to avoid loops
- Try to vectorize your code

  http://www.mathworks.com/support/tech-notes/1100/1109.html

THE END

- Thank you ☺
- Questions?