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Introduction to MATLAB

Matlab

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- Usage
  - Signal processing, image processing, testing and measurement, financial modelling and analysis, computational biology,…
- Expansions of MATLAB
  - Toolboxes for specific applications
  - E.g. Image Processing Toolbox, Image Acquisition Toolbox, Video and Image Processing Blockset, Statistics Toolbox, Wavelet Toolbox, …

Matlab - functions

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- Function list
  - http://www.mathworks.com/help/matlab/functionlist.html

- Tutorial
  - http://www.mathworks.com/help/pdf_doc/matlab/getstart.pdf

Image Processing Toolbox

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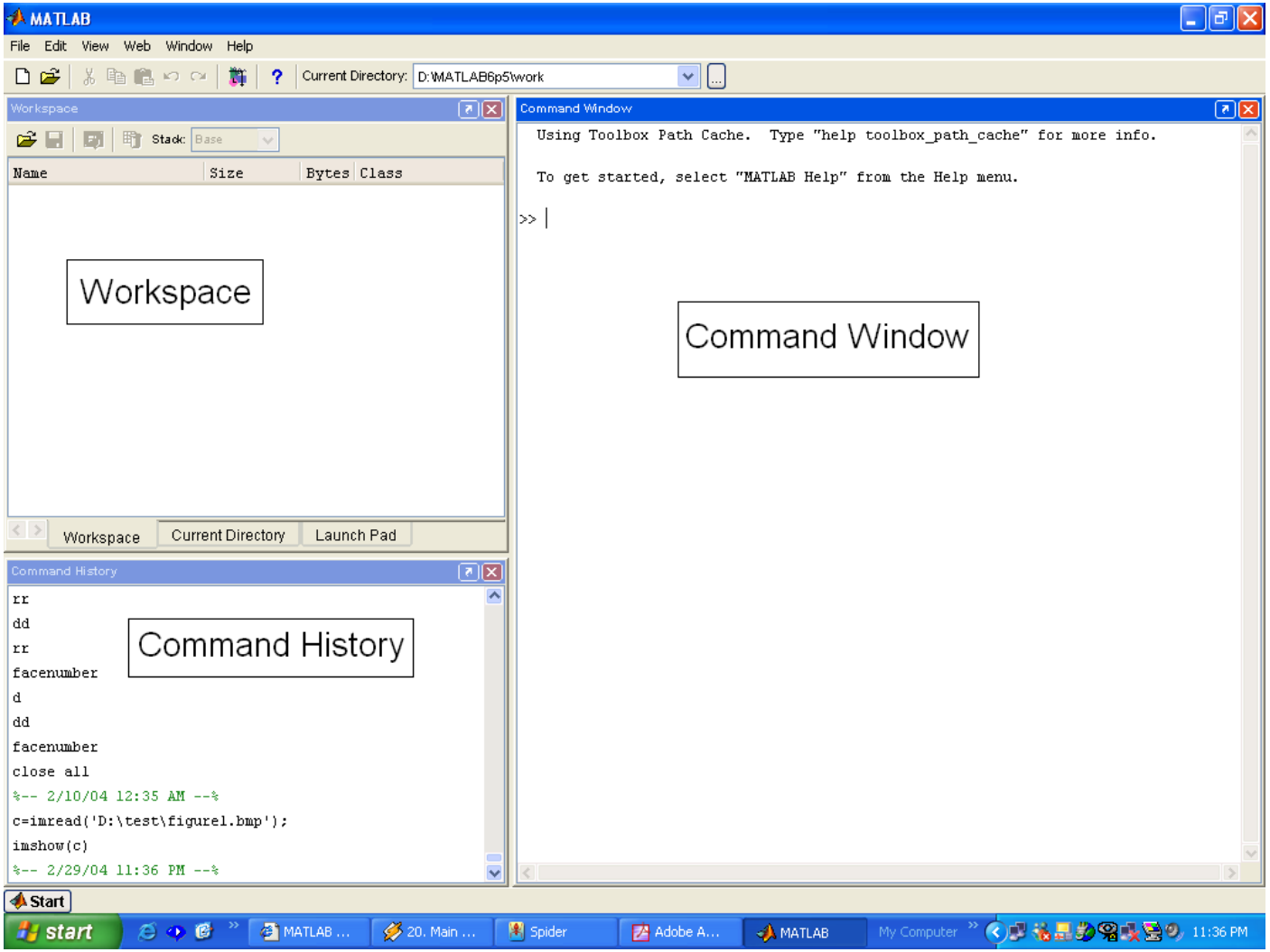
- Image analysis
  - Segmentation, Morphology, Feature extraction, Edge detection, …
- Image processing
  - Contrast enhancement, color space conversion, …
- FFT, DCT
- …

MATLAB - environment



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Matlab

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- Command window
  - Typing commands, outputs, errors
- Workspace
  - Variables, their values and types
- Command history
  - Used commands can be “drag and drop” to the command window

Command window

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- 3 + 4 - 7
- t = 3 + 4 – 7
- k = 3 + 4 - 7;
- k
- k;
- 3^2*4
- 2+2 / 1+1

Command window

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- 1/0 (Inf)
- 0/0 (NaN)
- MATLAB is Case Sensitive!
- K and k are different variables

Command window

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- MATLAB has a lot of built-in functions

- sin, cos, tan, asin, acos
- sin(pi/2)
- log, log10, log2
- log10(100)

- Do not overwrite built-in functions/variables
  - exist name

Vectors in MATLAB

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- v = [1, 2, 3, 4]
- v = [1 2 3 4]
- v = [1; 2; 3; 4]
- v = start: step: end
- v = 2:2:9
  - v = [2, 4, 6, 8]
- v = 2:5
  - v = [2, 3, 4, 5]
- v = linspace(1, 5, 10)
- v (4) = 0
- v (5:7) = 0
- v (1: 2: 7) = 0

Matrices in MATLAB

- A=[1 2 3; 4 5 6; 7 8 9]
- access(row, column)

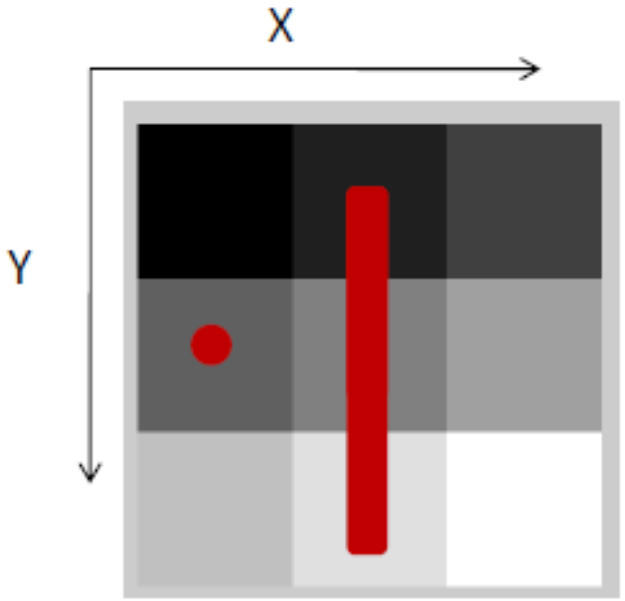
```
>> A(2,1)
ans = 4
```

- : full row/column

```
>> A(:,2)
ans =
2
5
8
```

- Interval

```
>> A(1:2,2)
ans =
2
5
```




```
A =
1   2   3
4   5   6
7   8   9
```

Operations

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- Matrix
  - +, -, *, /, ^, sqrt, sin, cos, ...
- Element-wise operations
  - .*, ./, .^
- size(A)
- sum(A), sum(A,1) – sum of columns
- sum(A,2) / sum of rows
- sum(sum(A)) – sum of all items
- sum(A(:))

Operations

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- >> A+A

```
ans =     2     4     6
          8    10    12
         14    16    18
```

- >> A*A

```
ans =    30    36    42
         66    81    96
        102   126   150
```

- >> A.*A

```
ans =     1     4     9
         16    25    36
         49    64    81
```

Timing

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- tic; commands; toc;
- In seconds
- In m-files

```
t0 = cputime
   Commands
t1 = cputime
fprintf('duration %g', t1=t0)
```

Variable preallocation

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```
tic
x = 0;
for k = 2:10000000
        x(k) = x(k-1) + 5;
end
toc
```

```
tic
x = zeros(1, 10000000);
for k = 2:10000000
        x(k) = x(k-1) + 5;
end
toc
```

MATLAB specific commands

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- We want to create array: $v(p) = \frac{p}{\sin(p)+2}$

- 1:

```
tic
for p = 1:100000
v(p) = (p/sin(p)+2); end
toc
```

- 2:

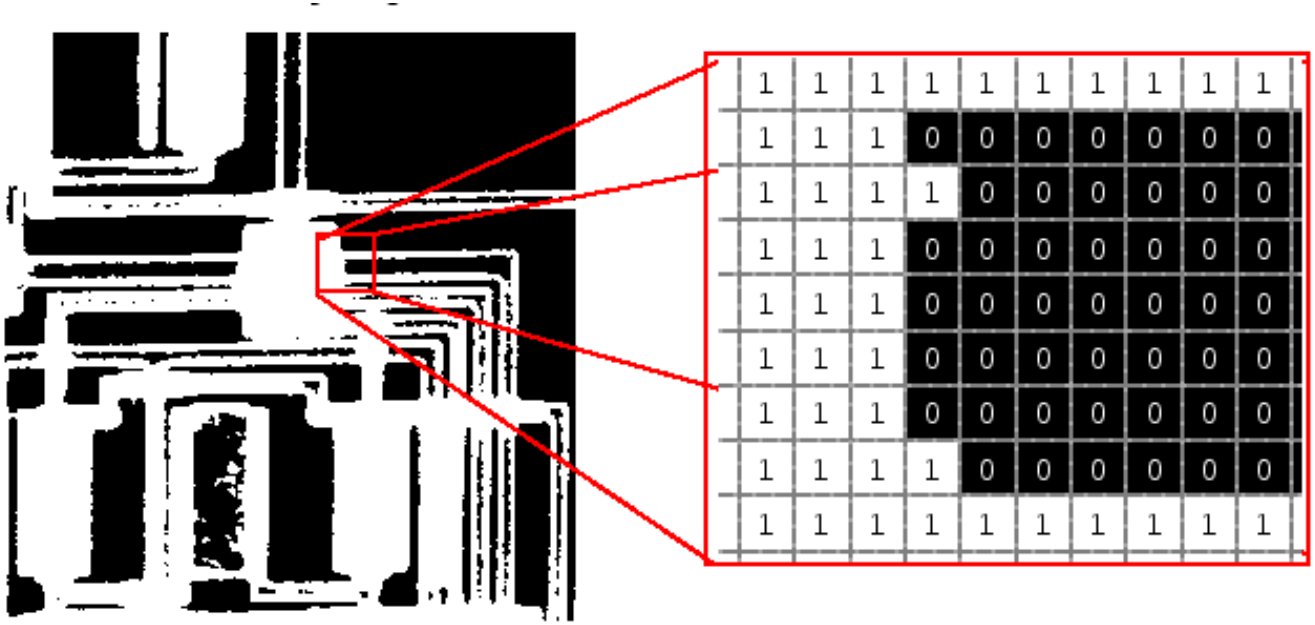
```
tic
v = zeros (1, 100000);
for p = 1:100000
v(p) = (p/sin(p)+2); end
toc
```

- 3:

```
tic
p = 1:100000;
v = (p./sin(p)+2);
toc
```

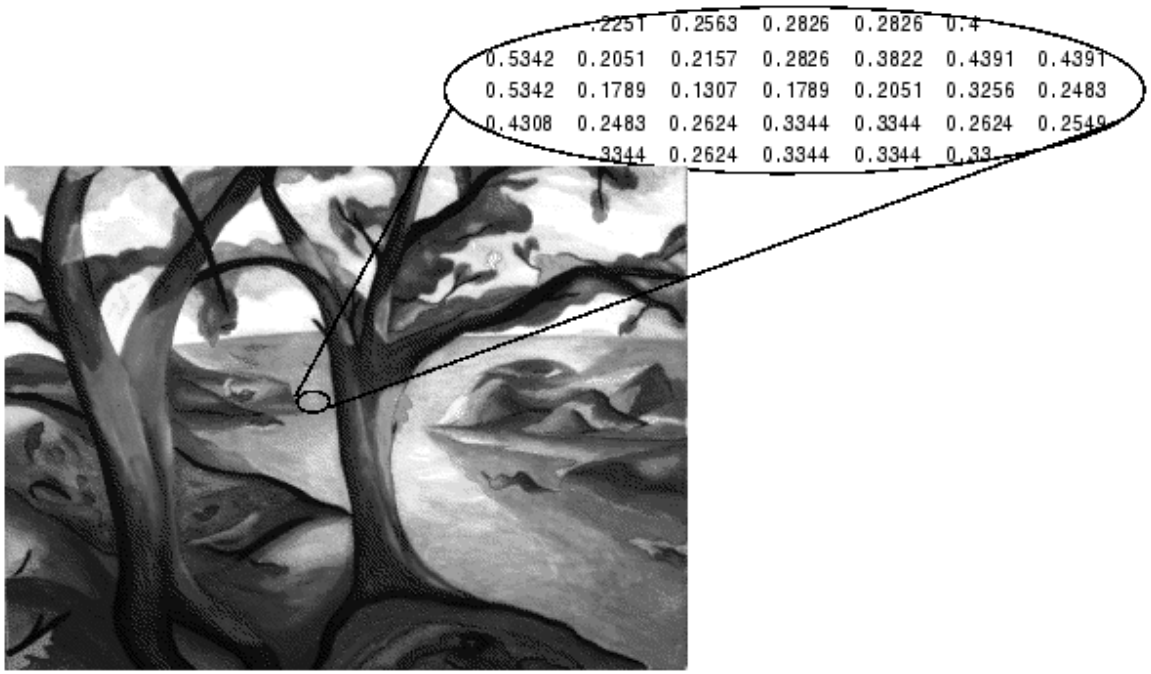
Images

- **Binary: {0,1}**
- Grayscale: uint8, double,…
- RGB: m x n x 3



Images

- Binary: {0,1}
- **Grayscale: uint8, double,…**
- RGB: m x n x 3



Images

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- Binary: {0,1}
- Grayscale: uint8, double,…
- **RGB: m x n x 3**

Grayscale image

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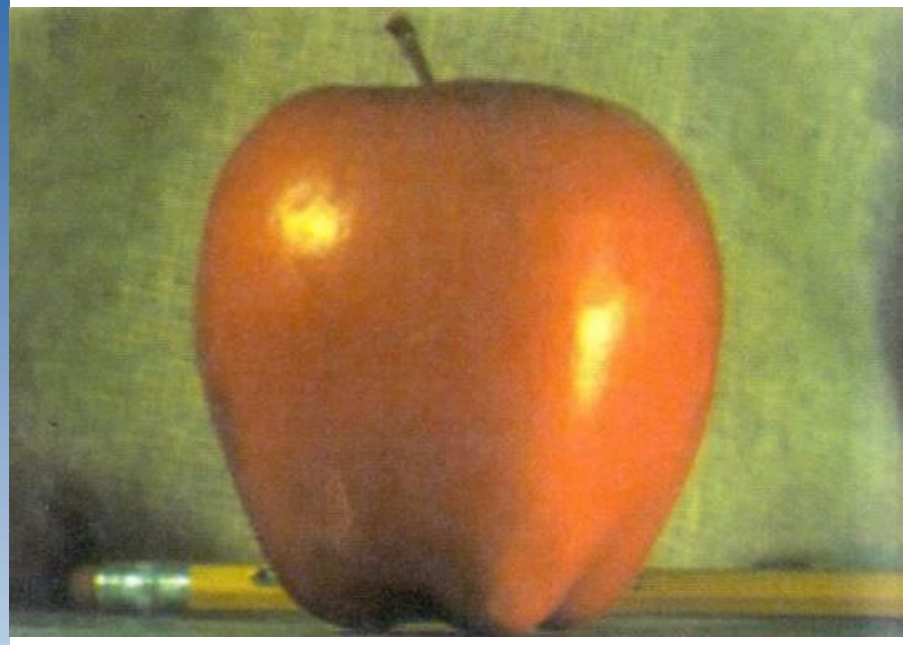
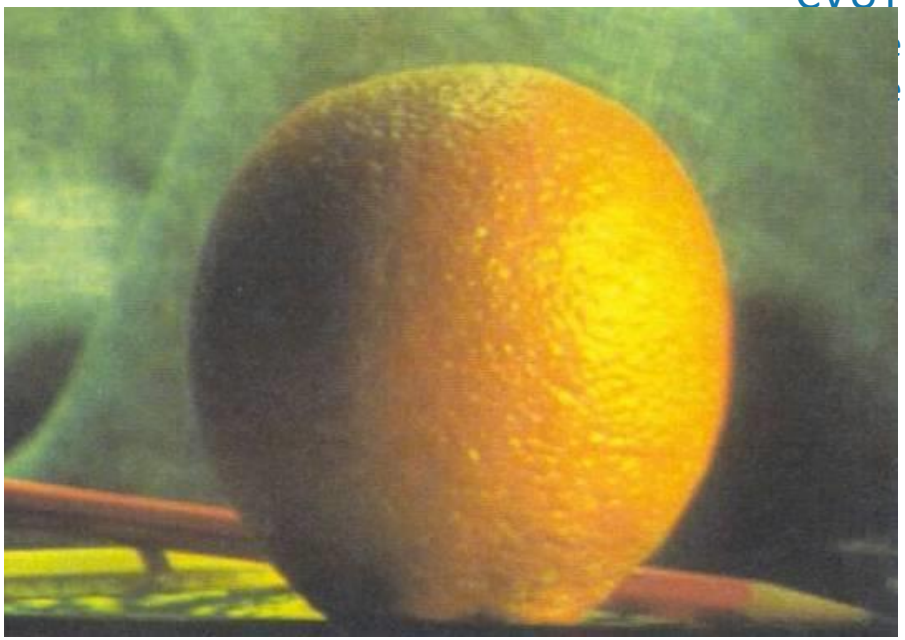
```
row = 256;
col = 256;
img = zeros(row, col);
img(100:105, :) = 0.5;
img(:, 50:55) = 1;
figure;
imshow(img);
```

How to combine 2 images?





How to combine 2 images?

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A a B size (540*380),

```
apple = imread('apple.jpg');
orange = imread('orange.jpg');
```

Brute force

```
% measure performance using stopwatch timer
tic
for i = 1 : size(apple, 1)
  for j = 1 : size(apple, 2)
                for k = 1 : size(apple, 3)
                          output(i, j, k) = (apple(i, j, k) +
  orange(i, j, k))/2;
                end
  end
end
toc
```

What is the time of the operation?

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A a B size(540*380)

```
apple = imread('apple.jpg');
orange = imread('orange.jpg');
```

Approach by using matrices

```
tic
  % measure performance using stopwatch timer
  output = (apple + orange)/2;
toc
```

? time

Performance optimization

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- Fast operations with vectors and matrixes
- Slow cycles

- How to improve the code:
  - http://www.mathworks.com/support/tech-notes/1100/1109.html

Useful shortcuts

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- Ctrl r
  - Comment selection
- Ctrl t
  - Uncomment selection
- Ctrl c
  - Interrupt computation
- why, spy