

CSE185

Introduction to Computer Vision

Lab 01: Image Processing in MATLAB

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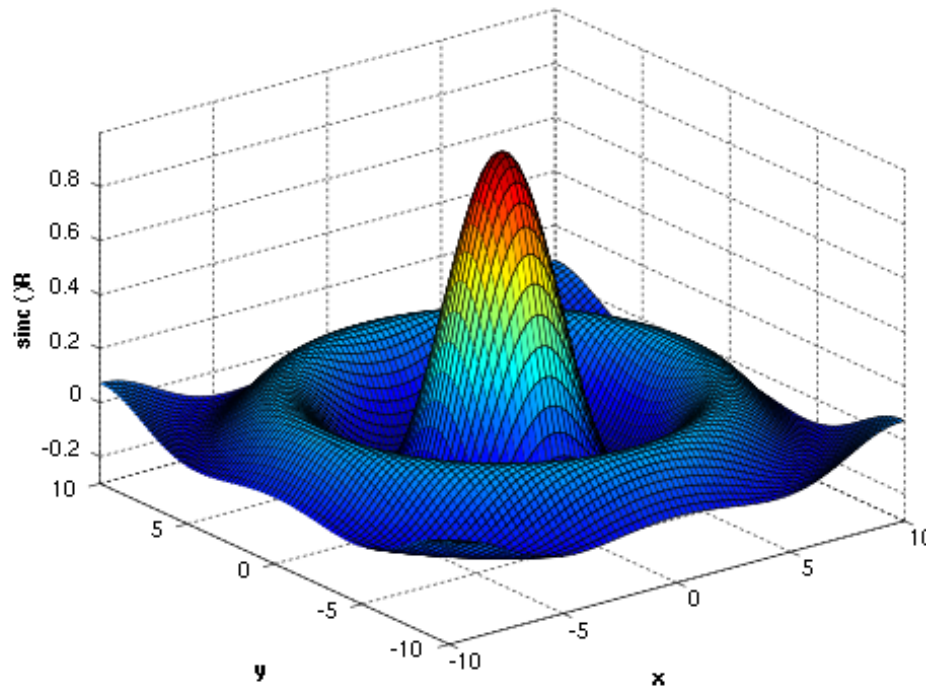
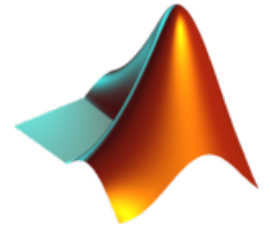
TA: Chun-Han Yao & Yi-Wen Chen

Lecture and Labs

- Lecture:
 - Monday 15:00 – 16:15
 - Tuesday 15:00 – 16:15
- Labs:
 - 02L: Monday 16:30 – 19:20
 - 03L: Monday 19:30 – 22:20
 - 04L: Friday 10:30 – 13:20
 - 05L: Monday 07:30 – 10:20
- The deadline of each lab is one week after announcement (before the start of the next lab)
 - Monday 16:30 for 02L, Monday 19:30 for 03L, Friday 10:30 for 04L, Monday 07:30 for 05L

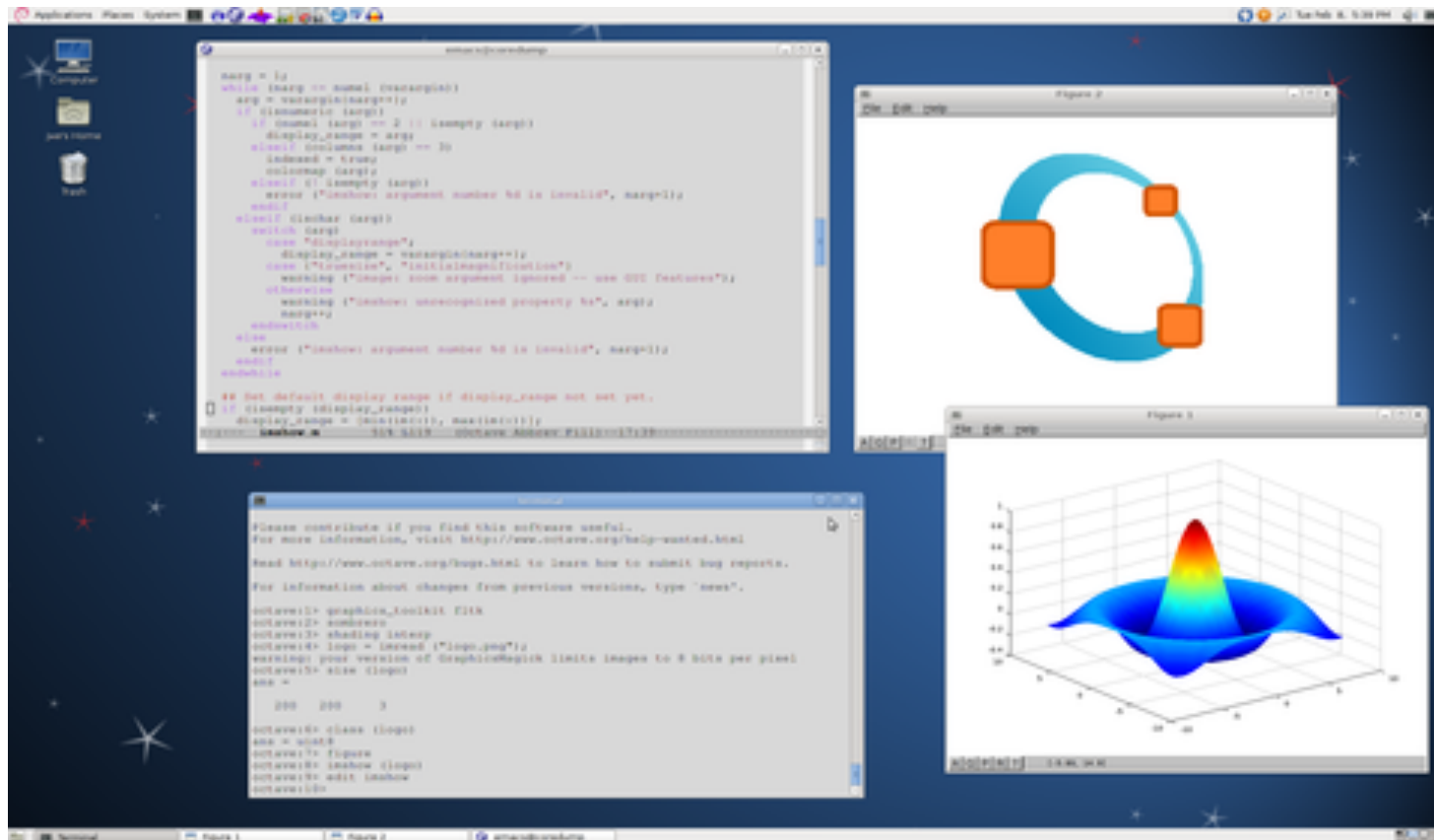
Introduction to MATLAB

- MATLAB is a numerical computing environment
- Allow easy operation on matrix, image, N-D data
- Easily plot and visualize data
- Simple GUI
- Interface with other languages (e.g. C/C++, Python)



Introduction to MATLAB

- MATLAB is NOT free (need license)
 - UC Merced has bought the license. Use your UC Merced email to create MathWorks account and download MATLAB
- GNU Octave is free and compatible with MATLAB



Variable

- Variable: no declaration, implicit type conversion

```
>> x = 10
```

```
x =
```

```
10
```

```
>> x = 'test'
```

```
x =
```

```
test
```

```
>> z = 10; y = z + 10
```

```
y =
```

```
20
```

```
>> y = z^2
```

```
y =
```

```
100
```

```
>> y = mod(z, 3)
```

```
y =
```

```
1
```

MATLAB use single quote for string

Vector

- Vector: use `[]` or `init:step:end`

```
>> vec = [1, 100]
vec =
     1    100
>> vec = 1:2:10
vec =
     1     3     5     7     9
```

- Use `()` to access elements (index starts from 1):

```
>> vec(3)
ans = 5
```

- Access part of vector:

```
>> vec(2:4)
ans =
     3     5     7
```

Matrix

- Matrix: use semicolon to separate each row

```
>> A = [1 2 3; 4 5 6; 7 8 9]
A =
     1     2     3
     4     5     6
     7     8     9
```

- Access elements:

```
>> A(2, 3)
ans =
     6
```

- Access sub-matrix (**Useful and Important!**):

```
>> A(1:2, 2:3)
ans =
     2     3
     5     6
```

Multiplication

- Matrix-vector multiplication:

```
>> A = [1 2 3; 4 5 6; 7 8 9];  
>> x = [1; 1; 1];  
>> A * x
```

```
ans =  
     6  
    15  
    24
```

$$A * x = \begin{pmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{pmatrix} * \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix} = \begin{pmatrix} 6 \\ 15 \\ 24 \end{pmatrix}$$

- Element-wise multiplication:

```
>> A = [1 2 3; 4 5 6; 7 8 9];  
>> B = [1 1 1; 2 2 2; 3 3 3];  
>> A .* B
```

```
ans =  
     1     2     3  
     8    10    12  
    21    24    27
```

$$A .* B = \begin{pmatrix} 1 \cdot 1 & 2 \cdot 1 & 3 \cdot 1 \\ 4 \cdot 2 & 5 \cdot 2 & 6 \cdot 2 \\ 7 \cdot 3 & 8 \cdot 3 & 9 \cdot 3 \end{pmatrix} = \begin{pmatrix} 1 & 2 & 3 \\ 8 & 10 & 12 \\ 21 & 24 & 27 \end{pmatrix}$$

If statement

- If statement

```
if EXPRESSION
    ...
end
```

- If-else statement

```
if EXPRESSION
    ...
else
    ...
end
```

```
if EXPRESSION
    ...
elseif EXPRESSION
    ...
else
    ...
end
```

Loop

- For loop

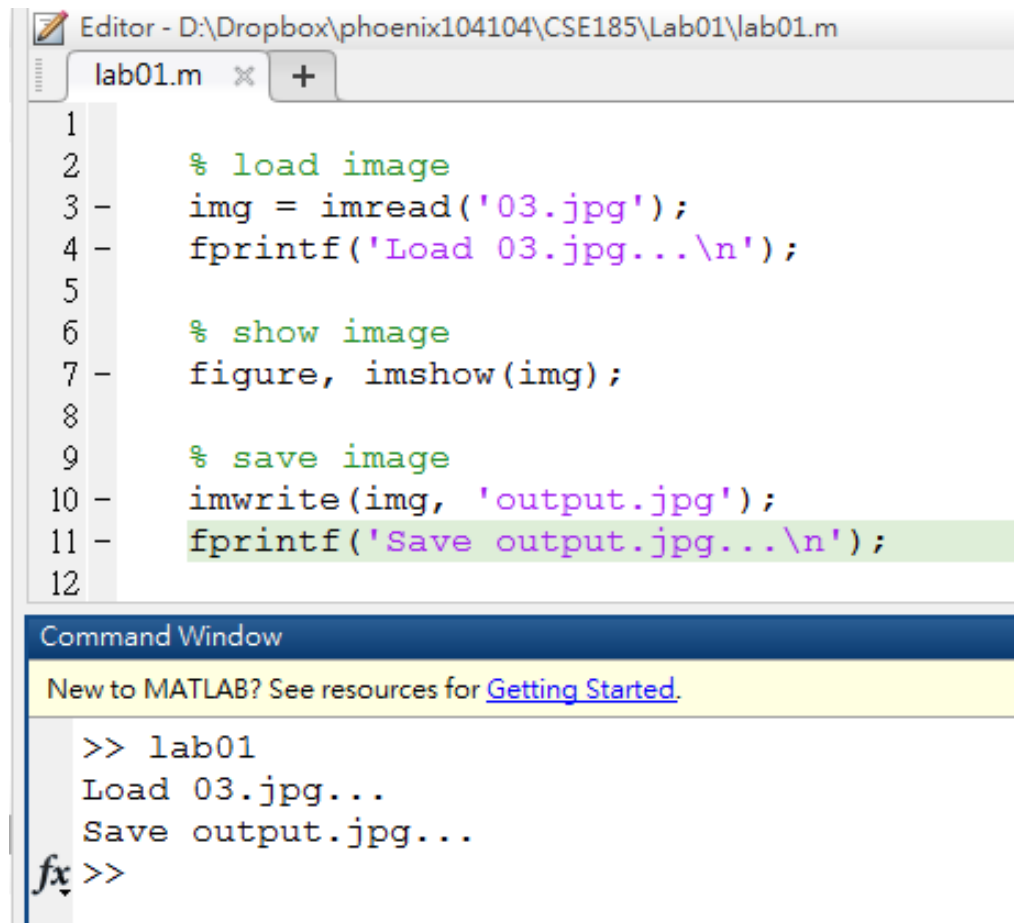
```
for i = 1:10  
    ...  
end
```

- While loop

```
while EXPRESSION  
    ...  
end
```

M file

- MATLAB executable file/script, function: *.m file
- Write commands in the script, and type script file name in command window to run the script



The screenshot displays the MATLAB environment. The Editor window at the top shows a script named 'lab01.m' with the following code:

```
1  
2 % load image  
3 - img = imread('03.jpg');  
4 - fprintf('Load 03.jpg...\n');  
5  
6 % show image  
7 - figure, imshow(img);  
8  
9 % save image  
10 - imwrite(img, 'output.jpg');  
11 - fprintf('Save output.jpg...\n');  
12
```

The Command Window at the bottom shows the execution of the script:

```
>> lab01  
Load 03.jpg...  
Save output.jpg...  
fx >>
```

Color Image

- Color image is a 3-D matrix in MATLAB: *Height* × *Width* × 3

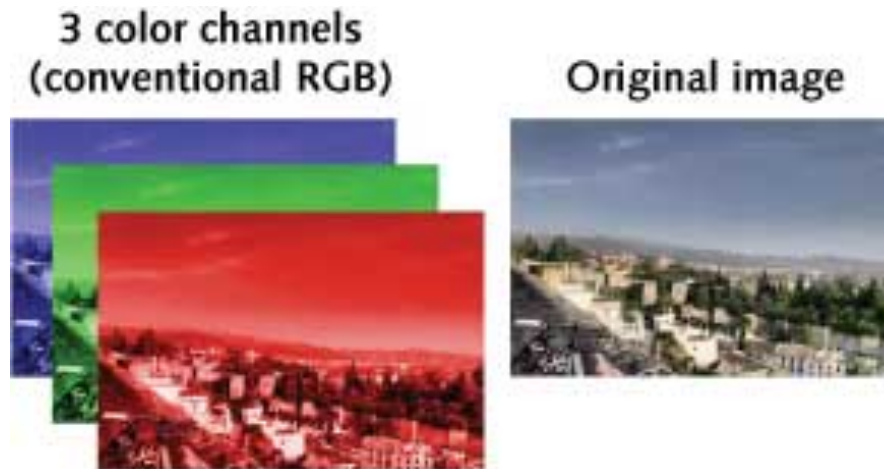


- Read image: `I = imread(filename);`
- Show image: `figure, imshow(I);`
- Save image: `imwrite(I, filename);`

Hint: type `help imread` in command window, or press F1 on function name to see the usage of the function

Color Image

- Color image is a 3-D matrix in MATLAB: $Height \times Width \times 3$



- $I(:, :, 1)$ is red channel
- $I(:, :, 2)$ is green channel
- $I(:, :, 3)$ is blue channel

: means select all elements in this dimension

Gray-scale Image

- Gray-scale image is a 2-D matrix in MATLAB: *Height* × *Width* (Only one intensity layer)



Gray-scale image



Color Image

- Use `size()` to check matrix dimension

```
>> I = imread('01_gray.jpg');  
>> size(I)  
ans =  
    300    400
```

Pixel Range and Type

- When loading image to MATLAB:
 - Default data type is uint8
 - Each pixel/element has a value between 0 and 255 (8 bits)
- Use `im2double()` to convert data type to double:
 - pixel range is between 0 and 1

```
>> I = imread('01.jpg');
```

```
>> I(1, 1)
```

```
ans =
```

```
    34
```

```
>> I = im2double(I);
```

```
>> I(1, 1)
```

```
ans =
```

```
    0.1333
```

The same as `I = double(I) / 255.0;`

Image Processing in MATLAB

- Set the value of green channel to zero



Image Processing in MATLAB

- Convert RGB to Y (gray-scale)

$$Y = 0.299 \times R + 0.587 \times G + 0.114 \times B$$



- Do NOT use `rgb2gray()` function in MATLAB

Reference: RGB to YUV <https://en.wikipedia.org/wiki/YUV>

Image Processing in MATLAB

- Rotate image 90 degree: use `imrotate()`



Image Processing in MATLAB

- Crop image boundary: extract sub-matrix



Image Processing in MATLAB

- Crop image boundary: extract sub-matrix

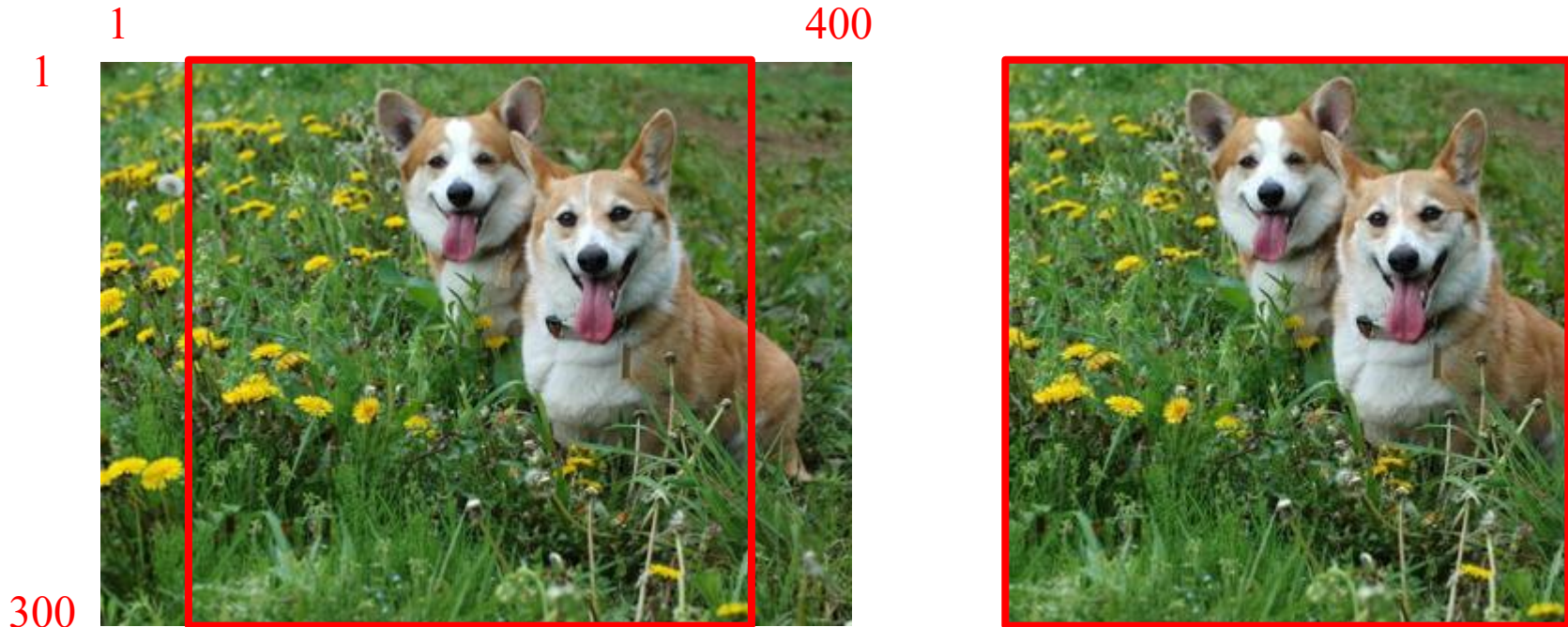


Image Processing in MATLAB

- Horizontally flip image: use `flip()`



Image Processing in MATLAB

- Combine 4 images into one big image with 2 x 2 grid



Image Processing in MATLAB

- Combine 4 images into one image with 2 x 2 grid
- Hint: use `zeros(Height, Width, 3, 'uint8')` to create a canvas/matrix first, and consider each image as a sub-matrix of the canvas
- The size of our testing image is $300 \times 400 \times 3$, use 10 pixels for separations:

```
I1 = imread('01.jpg');  
canvas = zeros(300 * 2 + 10, 400 * 2 + 10, 3, 'uint8');  
canvas(1:300, 1:400, :) = I1;
```

Image Processing in MATLAB

- Use (:) to convert image/matrix to vector
 - matrix in MATLAB is column-major

$$A = \begin{pmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{pmatrix} \quad A(:) = \begin{pmatrix} 1 \\ 4 \\ 7 \\ 2 \\ 5 \\ 8 \\ 3 \\ 6 \\ 9 \end{pmatrix}$$

- Use reshape () to convert vector to image/matrix

```
>> I = imread('01.jpg');
```

```
>> I = I(:);
```

```
>> size(I)
```

```
ans =
```

```
360000      1
```

```
>> I = reshape(I, 300, 400, 3);
```

```
>> size(I)
```

```
ans =
```

```
300    400     3
```

The size of image is 300×400×3

The size of vector is 360000×1

Image Processing in MATLAB

- Average two image vectors, and convert the vector back to image



Lab 01 Assignment

1. Set green channel to zero, and save as **green.jpg**
2. Convert image from RGB to gray scale without using built-in functions, and save as **gray.jpg**
3. Rotate 90 degrees, and save as **rotate.jpg**
4. Crop the image given the upper left point (30, 100) and lower right point (270, 300), and save as **crop.jpg**
5. Horizontally flip the image, and save as **flip.jpg**
6. Combine 4 images (01.jpg ~ 04.jpg) into one matrix with 2 x 2 grid and 10 pixels separations, and save as **combine.jpg**
7. Convert images (05.jpg and 06.jpg) to vectors, average them, and save as **average.jpg**
8. Upload all output images and your **lab01.m**

* For problem 1 – 5, choose 01.jpg as the input only.

Tips

- Without the ending semicolon, MATLAB will print the value of this function/variable
- Use command `close all;` to close all figures at once
- Use command `clear all;` to delete all variables in workspace
- Use command `clc;` to clean/flush command window
- When using submatrix indexing (`index1:index2`), both the indexes are included
 - `x(1:300)` counts from 1 to 300, totally 300 elements
 - `x(300:600)` counts from 300 to 600, totally 301 elements

Reference

- MATLAB: <http://www.mathworks.com/products/matlab/>
- Octave: <https://www.gnu.org/software/octave/>
- Introduction to MATLAB with Image Processing
http://www.slideshare.net/Sutanshu_Raj/introduction-to-matlab-with-image-processing-5495912