CSE185
Introduction to Computer Vision
Lab 01: Image Processing in MATLAB

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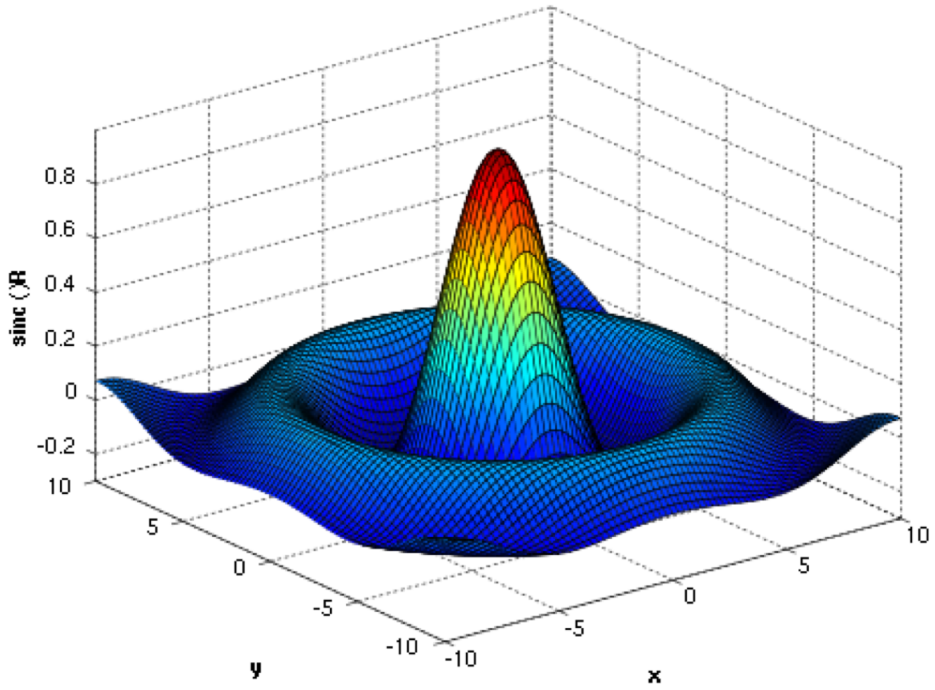
Lecture and Labs

- Lecture:
  - Monday 15:00 – 16:15 @ COB2 130
  - Tuesday 15:00 – 16:15 @ COB2 130
- Labs:
  - 02L: Monday 16:30 – 19:20 @ COB1 281
  - 03L: Monday 19:30 – 22:20 @ COB1 281
  - 04L: Friday 10:30 – 13:20 @ SE1 100
  - 05L: Monday 07:30 – 10:20 @ COB1 281

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)



Variable

- Variable: no declaration, implicit type conversion

```
>> x = 10
x =
    10
>> x = 'test' (use single quote for string)
x =
test
>> z = 10; y = z + 10
y =
    20
>> y = z^2
y =
    100
>> y = mod(z, 3)
y =
    1
```

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:

```
>> 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

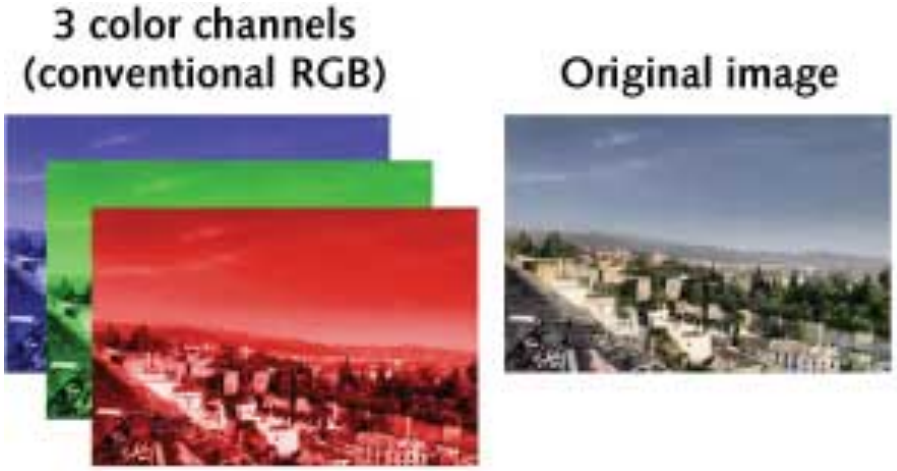
Editor - D:\Dropbox\phoenix104104\CSE185\Lab01\lab01.m

lab01.m

```
1
2       % load image
3 -     img = imread('test01.jpg');
4
5       % show image
6 -     figure, imshow(img);
7
8       % save image
9 -     imwrite(img, 'output.jpg');
10
11
```

Color Image

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

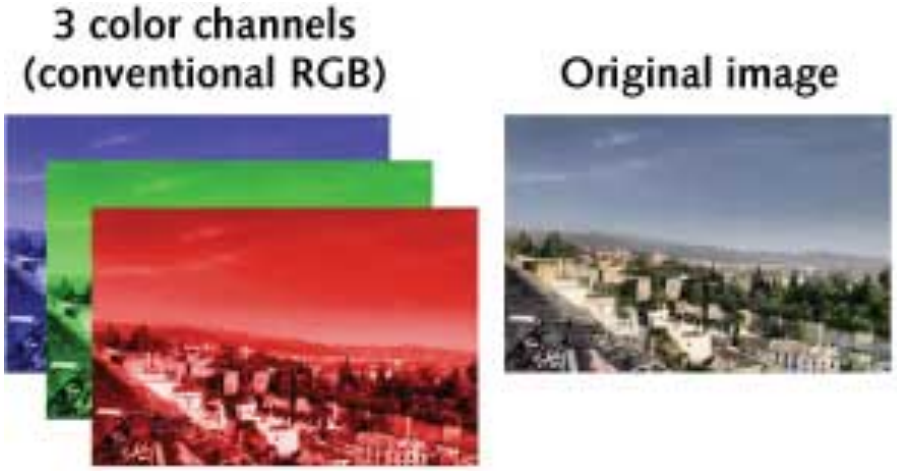


- Read image: `I = imread(filename);`
- Show image: `figure, imshow(I);`
- Save image: `imwrite(I, filename);`

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: $Height \times Width$

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);  The same as I = double(I) / 255.0;
>> I(1, 1)
ans =
    0.1333
```

Image Processing in MATLAB

- Set the value of green channel to zero

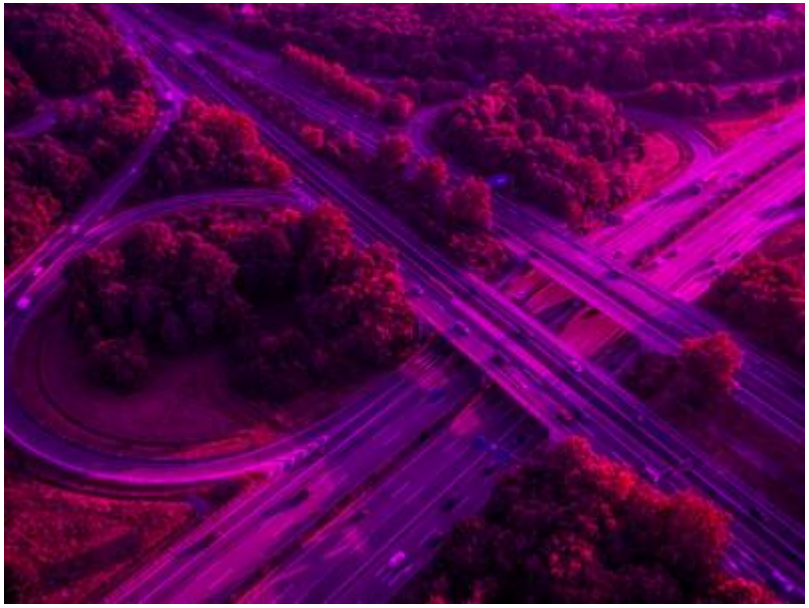


Image Processing in MATLAB

- 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 given the upper left and lower right positions

Image Processing in MATLAB

- Horizontally flip image: use `flip()`

Image Processing in MATLAB

- Combine 4 images into one 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 300×400×3, 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

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

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

```
>> I = imread('01.jpg'); ⇐ The shape of image is 300×400×3
>> I = I(:);
>> size(I)
ans =
    360000         1
>> I = reshape(I, 300, 400, 3);
>> size(I)
ans =
    300    400     3
```

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 degree, and save as rotate.jpg
4. Crop any image given the upper left point (30, 100) and lower left 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.**

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