Handbook Lab 1

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Digital Images

A digital image is composed of a finite number of elements, each of which has a particular location and value, called Pixels.

Digital Images Formation

1 Sampling converts continuous signal into discrete signal, so that it can be quantized. Sampling rate is the frequency at which a signal is sampled.

Nyquist ratio: A good sampling rate must be twice the highest frequency of the signal.

2 Quantization limits the number of allowed amplitude values, so that a computer can interprent them.

Note: Analog signals are not necessarily continuous. Digital signals are not necessarily discrete.

Images in MATLAB

MATLAB stores images in *matrices*, in which each *element* of the matrix corresponds to a *single pixel* in the displayed image.

Import an image with `imread`

The function `imread` impots an image into into MATLAB Workspace.

```
rgb_img = imread("peppers.png");
```

now the data in the `pepper.png` image is stored in the matrix variable named `rgb_img`.

Show an image using `imshow`

The function `imshow` can visualize the data in the `rgb_img` matrix variable.

```
imshow(rgb_img);
```

Convert an RGB (Truecolor) image into Grayscale (Intensity)

For demonestration reasons, we will convert the `rgb_img` into grayscale. This is done using `rgb2gray` function.

```
gray_img = rgb2gray(rgb_img);
imshow(gray_img);
```

Size of images in Workspace

The size of an image = rows x columns. you can use the `size` function to view the size.

```
size(gray_img) % We ommited the ';' so that the answer appears instantly.
```

```
ans = 1×2
   384   512
```

The ans shows that the size is `384 512.` This means the `gray_img` matrix contains 384 rows and 512 columns.

Let's check the size of the `rgb_img`

```
size(rgb_img)
```

```
ans = 1×3
   384   512     3
```

The ans shows that the size is `384 512 3`. **What is this 3?**

In RGB the image is stored in 3 matrices correponding to Red, Green and Blue intensity levels, forming a 3d matrix. Hence, the number 3 refers to the number of channels in the image. There are other image types that store image information in multiple channels. We will discuss them later.

Other information about images

you can use the whos function to get more information about your image other than size. here is an example:

```
whos("rgb_img") % pay attention to the double quotation.
```

```
  Name           Size                Bytes  Class    Attributes

  rgb_img      384x512x3            589824  uint8
```

We already knew the name and size, let's discuss Bytes and Class.

- **Class** tells you how many Bytes per element are used (Bit-depth). `uint8` means that 8 bits are used to represent each element.
- **Bytes** tells you that the image occupies **589,824** bytes (0.59 MB) in the MATLAB workspace. **Not** the file size on device storage.

Example

Determine the number of bytes necessary to store an *uncompressed* RGB color image of size 640 × 480 pixels using 8, 12,16, and 64 bits per color channel.

```
store_8 = 384 * 512 * 3 * (8/8); % 589,824
store_12 = 384 * 512 * 3 * (12/8); % 884,736
store_16 = 384 * 512 * 3 * (16/8); % 1,179,648
store_64 = 384 * 512 * 3 * (64/8); % 4,718,592
```

bit-depth	rows	columns	channels	bytes/element	size in bytes
8	384	512	3	1	589,824
12	384	512	3	1.5	884,736
16	384	512	3	2	1,179,648
64	384	512	3	8	4,718,592

Split the image into channels

`imsplit` splits multichannel image into its individual channels.

```
[c1,c2,c3,ck] = imsplit(I)
```

returns a set of k images representing the individual channels in the k-channel image `I`.

```
[R, G, B] = imsplit(rgb_img);
```

Colorizing the channels for RGB

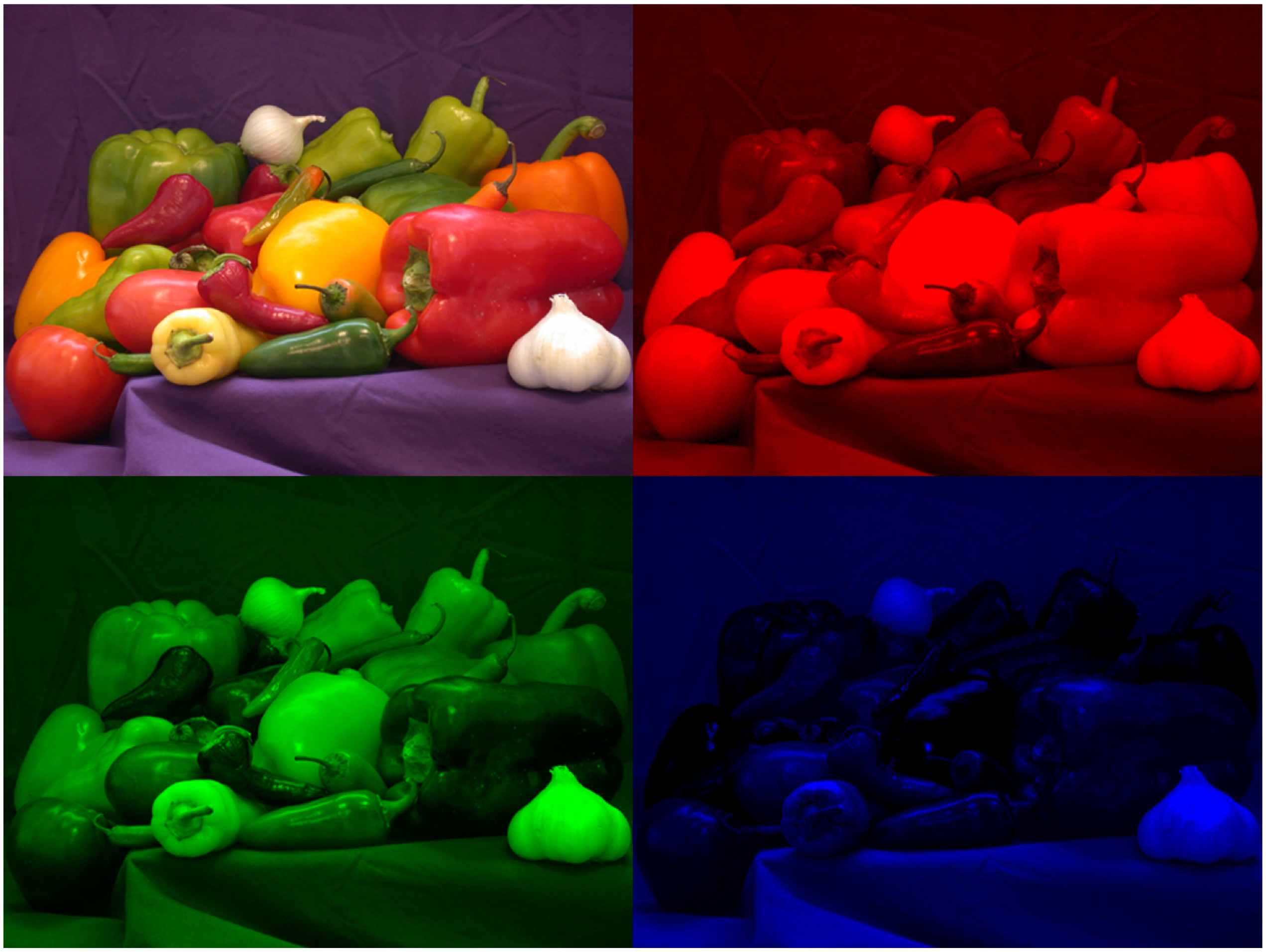
```
allBlack = zeros(size(rgb_img,1,2),class(rgb_img));
justR = cat(3,R,allBlack,allBlack);
```

```
justG = cat(3,allBlack,G,allBlack);
justB = cat(3,allBlack,allBlack,B);
```

Visualize the results

There are many ways to show the output. However, it is easier to use the `montage` function in this case.

```
montage({rgb_img, justR, justG, justB}, 'Size', [2 2]);
```



Save the result

```
imwrite(justR, "r.png");
imwrite(justG, "g.png");
imwrite(justB, "b.png");
```

Summary

Term	Description
Pixel	The smallest unit of an image, representing a single color or intensity value in a grid format.

Sampling	The process of converting a continuous signal into discrete data points (time or space).
Sampling rate	The frequency at which data is sampled; in image processing, it refers to how many pixels are captured per unit area.
Nyquist Ratio	In signal processing, this is twice the highest frequency of a signal, ensuring accurate reconstruction during sampling.
Quantization	The process of converting continuous amplitude values into a set of discrete levels.
Bit-depth	The number of bits used to represent the intensity or color value of each pixel in an image.

Function/Class	**Description**
`imread`	reads an image from graphics file.
`imshow`	displays an image in Handle Graphics figure.
`imwrite`	writes an image to graphics file.
`whos`	lists all the variables in the current workspace, together with information.
`rgb2gray`	converts an RGB image to a grayscale image by removing color information.
`uint8`	represents data in unsigned 8-bit **integer** format, commonly used for storing image pixel values (0 to 255).
`uint16`	represents data in unsigned 16-bit **integer** format, used for higher precision images (0 to 65535).
`double`	represents double-precision floating-point numbers, offering even higher precision for data representation.
`montage`	display multiple image frames as rectangular montage
`cat`	`CAT(DIM,A,B)` concatenates the arrays A and B along the dimension DIM.