University of Diyala
Computer Science Department
Image Processing
3rd Class
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Image Processing

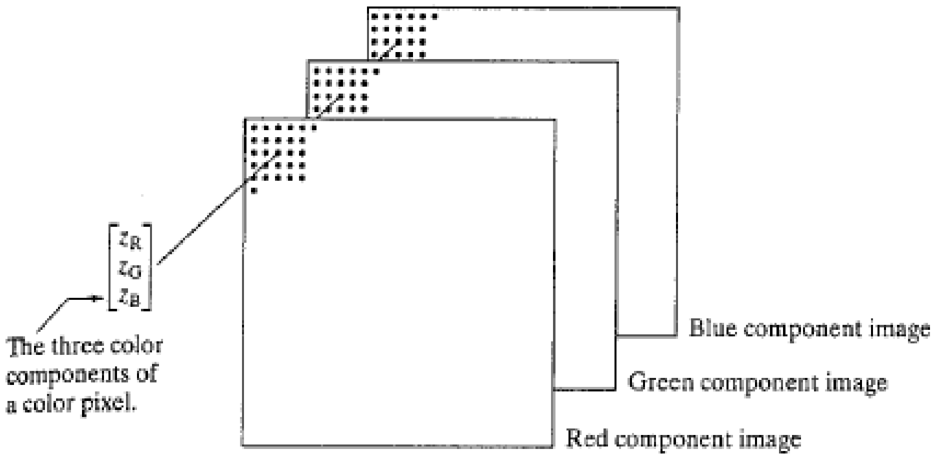
معالجة صور

7th lecture

Color Image Processing

RGB Images

An *RGB* color image is an *M×N×3* array of color pixels, where each color pixel is a triple corresponding to the red, green, and blue components of an *RGB* image at a specific spatial location (see the figure below). The number of bits used to represent the pixel values of the component images determines the bit depth of an *RGB* image. For example, if each component image is an 8-bit image, the corresponding RGB image is said to be 24 bits deep.



$\begin{bmatrix} z_R \\ z_G \\ z_B \end{bmatrix}$
The three color components of a color pixel.
Blue component image
Green component image
Red component image

Let fR, fG, and fB represent three RGB component images. An RGB image is formed from these images by using the cat (concatenate) operator to stack the images:

```
rgb_image = cat(3, fR, fG, fB)
```

The following commands extract the three components images:

```
fR = rgb_image(:, :, 1);
fG = rgb_image(:, :, 2);
fB = rgb_image(:, :, 3);
```

Converting to other color spaces

1- NTSC Color Space

The NTSC color system is used in television in the United States. One of the main advantages of this format is that gray-scale information is separate from color data, so the same signal can be used for both color and monochrome television sets. In the NTSC format, image data consists of three components: *luminance* (Y), *hue* (I), and *saturation* (Q), where the choice of the letters YIQ is conventional. The luminance component represents gray-scale information, and the other two components carry the color information of a TV signal. The YIQ components are obtained from the RGB components of an image using the transformation

$$\begin{bmatrix} Y \\ I \\ Q \end{bmatrix} = \begin{bmatrix} 0.299 & 0.587 & 0.114 \\ 0.596 & -0.274 & -0.322 \\ 0.211 & -0.523 & 0.312 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

Note that the elements of the first row sum to 1 and the elements of the next two rows sum to 0. This is as expected because for a gray-scale image all the RGB components are equal, so the I and Q components should be 0 for such an image. Function `rgb2ntsc` performs the transformation:

```
yiq_image = rgb2ntsc(rgb_image)
```

where the input RGB image can be of class `uint8`, `uint16`, or `double`. The output image is an $M \times N \times 3$ array of class `double`. Component image `yiq_image(:, :, 1)` is the luminance, `yiq_image(:, :, 2)` is the hue, and `yiq_image(:, :, 3)` is the saturation image.

Similarly, the RGB components are obtained from the YIQ components using the transformation:

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1.000 & 0.956 & 0.621 \\ 1.000 & -0.272 & -0.647 \\ 1.000 & -1.106 & 1.703 \end{bmatrix} \begin{bmatrix} Y \\ I \\ Q \end{bmatrix}$$

IPT function `ntsc2rgb` implements this equation:

```
rgb_image = ntsc2rgb(yiq_image)
```

2- *The YCbCr Color Space*

The YCbCr color space is used widely in digital video. In this format, luminance information is represented by a single component, Y, and color information is stored as two color-difference components, Cb and Cr. Component Cb is the difference between the blue component and a reference value, and component Cr is the difference between the red component and a reference value (Poynton [1996]). The transformation used by IPT to convert from RGB to YCbCr is

$$\begin{bmatrix} Y \\ Cb \\ Cr \end{bmatrix} = \begin{bmatrix} 16 \\ 128 \\ 128 \end{bmatrix} + \begin{bmatrix} 65.481 & 128.553 & 24.966 \\ -37.797 & -74.203 & 112.000 \\ 112.000 & -93.786 & -18.214 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

The conversion function is

```
ycbcr_image = rgb2ycbcr(rgb_image)
```

The input RGB image can be of class `uint8`, `uint16`, or `double`. The output image is of the same class as the input. A similar transformation converts from YCbCr back to RGB:

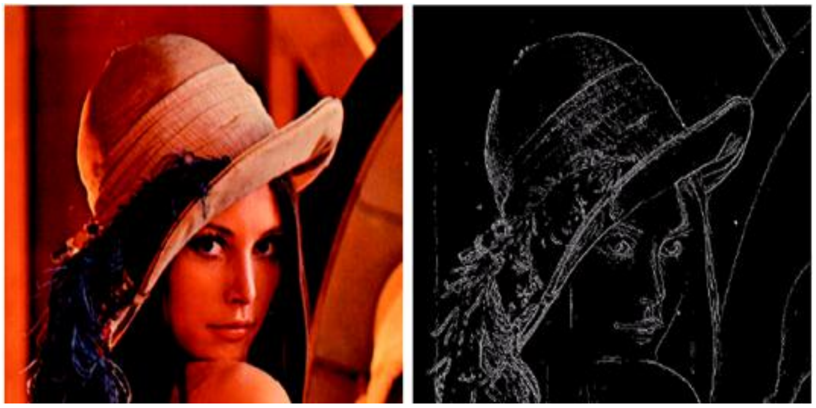
```
rgb_image = ycbcr2rgb(ycbcr_image)
```

Color Segmentation

Partition an image into regions --- Segmentation.

Color Edge Detection

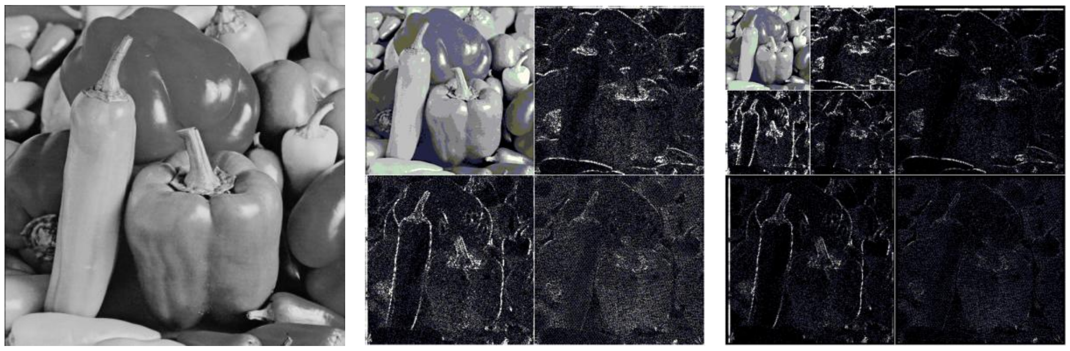
Computing the direction of maximum rate of change of the color at (x,y).



Frequency domain

Discrete wavelet transform

In DWT, the input image is divided into four non-overlapping multi-resolution sub-bands, namely LL1 (approximation coefficients), LH1 (vertical details), HL1 (horizontal details) and HH1 (diagonal details). The sub-band (LL1) is processed further to obtain the next coarser scale of wavelet coefficients, until some final scale 'N' is reached. When 'N' is reached, 3N + 1 sub-band are obtained consisting of the multi-resolution sub-bands. Which are LLX and LHX, HLX and HHX where 'X' ranges from 1 until 'N'. Generally, most of the image energy is stored in the LLX sub-bands. The 2D DWT decomposition is depicted in the following figures.

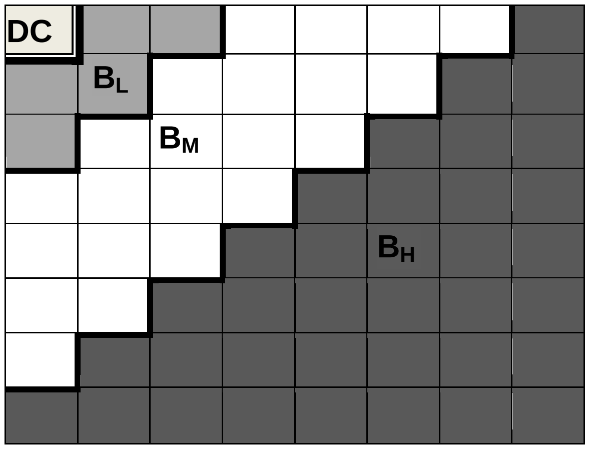


(a) **(b)** **(c)**

(a) Original Peppers image, **(b)** Peppers image with one-level of DWT decomposition, **(c)** Peppers image with two-levels of DWT decomposition.

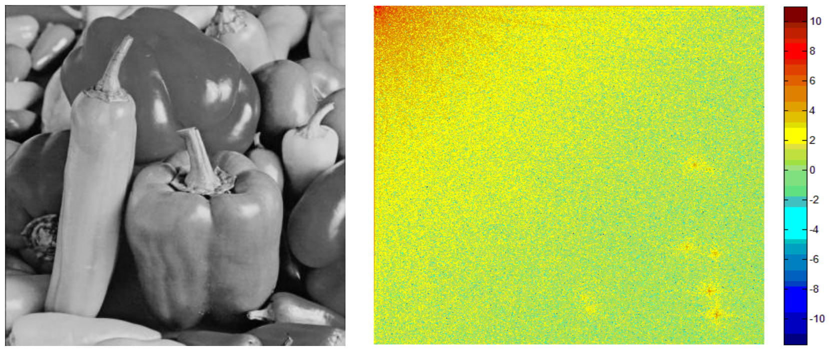
Discrete cosine transform

DCT transform is a typical scene for image processing and digital signal processing with advantages of high compression ratio, small bit error rate, good information integration ability and good synthetic effect of calculation complexity. The following figure represents the DCT block which composed of several frequency bands; The first zone represents the single direct current (DC) coefficient, the next delimited zone is the low frequency coefficients of the block (BL), the dark zone represents the height frequency band (BH) , whereas the white zone represents the middle frequency coefficients of the block (BM).



DCT block components.

The DCT is a technique for converting a signal into elementary frequency components. It represents an image as a sum of sinusoids of varying magnitudes and frequencies. The following figure shows the 2D DCT for the peppers image that almost all of the energy is in the top left corner.



(a) **(b)**

(a) Original Peppers image and **(b)** its 2D DCT.