Lecture 3: Digital Images

Definitions

- *Image*: a **spatial presentation of an object**, a 2-D or 3-D scene or another image.
- An image may be abstractly thought of as a **continuous function** defining a rectangular region of a plane.
- *Image Matrix*: representing **quantized intensity** values.
- *Pixels*: the points at which an image is **sampled**.
- *Intensity*: determined via **sampling** over region of pixel.
- Binary Images: 2 intensity values.
- *Gray Scale*: using luminance information, e.g. 8 bit int 0-255.
- *Color of light*: characterized by the **wavelength** of the light.
- *Visible light*: an electromagnetic wave **400nm** ~ **700nm**.
- *Digital Image*: composed of a **collection of pixels**.
- *Resolution*: No. of pixels per a unit or the dots per inch (**dpi**).
- *Sizing*: No. pixels * bits/pixel = No. bits.
- *Image Format*:
  - Captured image format
  - Stored image format: Bit representation on disk (usually compressed).
- Captured Image Parameters:
  - Spatial resolution: pixels (H * V).
  - Color encoding: bits/pixel.

Images Format

RGB

- A type of **computer color display output signal**.
- Consist of separately adjustable red, green, and blue signal or components.

Bitmap

- A common PC graphics file format.
- Pattern of dots with the extension **.bmp**.

Representation

Link

- Color model
- Number of channels
- Color depth
- Storage layout
- Pixel aspect ratio
- Compression

Image Acquisition

- Intensity: determined via sampling over **region of pixel**.

Image Representation

Digital Image Representation

- Optical image: A(x, y) the brightness at position (x, y).

Image Characteristics

Image Resolution

- Measure of iamge quality.
- No. of pixels, M * N.

Dynamic range

- Measure of the range of brightness values
  - 1 bit (binary)
  - 8 bits (grey)
  - 12 bits (medical)
  - 16 bits (Astronomical)
  - 24 bits (color image)
  - Note: n bpp has 2^n gray levels.

Image Sampling

- Digital: sampled from a **continuous** image.
- *Quantize* the **intensity values** at the sampled points into **discrete** levels.
- Intensity value: integer.
- No. *intensity values*: **quality** of the stored digital image.

Image Resolution

- *Accuracy*: affected by the distance between grid points.

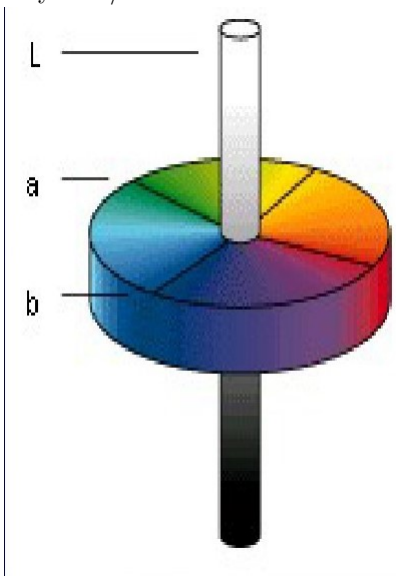
The Image Media Type

- Facsimile (low quality)
  - Over a telephone line.
  - 100 ~ 200 dpi.
- Document (medium quality)
  - Business documents.
  - 300 dpi.
- Photographic (high quality)
  - Requirement: > 300 dpi.

24-Bit Color Image of RGB

- Each channel with 8 bits(256).
- *CLT*: **Color Lookup Tables**: use index or code value instead of 24-bit.

L*a*b Color Model

- L: luminance
- a: red/green balance
- b: yellow/blue balance
- 

YUV Color Model

- For TV.
- Y: luminance value
- Luma Y': gamma-corrected.
- UV: chrominance
- Reason for gamma-correction: Human's response is **not linear** to the driving **voltage** of display device.
- The difference between a color & a reference white: at the same luminance.
- U = B' - Y'
- V = R' - Y'

YCbCr Color Model

- Used in MPEG.
- Cb = ((B' - Y')/1.772)+0.5
- Cr = ((R' - Y')/1.402)+0.5

YIQ Color Model

- Use in **NTSC** (National Television System Committee).
- Y' is the same as in YUV.
- I and Q are rotated version of U and V by **33°**.

CMY && CMYK Color Model

- CMY: Cyan, Magenta, Yellow.
- **Invertible** transformation from CMY to RGB.
- K: real black: cheaper ink and better than using the mixing colored ink.
- invertible

$$\begin{bmatrix} C \\ M \\ Y \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} - \begin{bmatrix} R \\ G \\ B \end{bmatrix} \quad \begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} - \begin{bmatrix} C \\ M \\ Y \end{bmatrix}$$

Number of Channels

- The **dimensionality** of the color model.
- From RGB to CMYK:
  1. K = 1 - max(R', G', B')
  2. C = (1 - R' - K) / (1 - K)
  3. M = (1 - G' - K) / (1 - K)
  4. Y = (1 - B' - K) / (1 - K)

Color Depth

- For n bits of information, there are 2^n colors.
- Determined by **video card memory constraints**.

Pixel Aspect Ratio

- Width / Height.
- Square / Rectangular.

Compression

- The amount of compression achieved depends on the **image content**.

Basic Operations

- Editing
- Point operations
- Filtering
- Compositing
- Geometric Transforms
- Conversion

1. Complement Image: O(x, y) = 255 - I(x, y). Image **Enhancement** / **Restoration**.
2. Image Histograms: Distribution of image pixels.
    - The highest peak: background.
    - The second highest peak: foreground.
    - Set a threshold to filter the background.

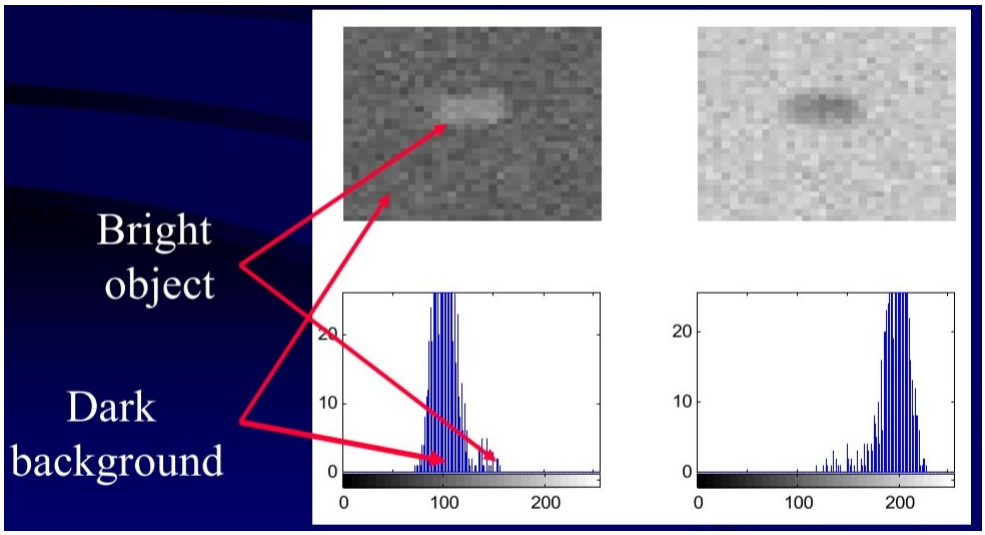


Figure 1: Bimodal Histograms

3. Cumulative Histogram: $CH(J) = sum_{j<=J}(N_j)$