Digital Image Processing

Lecture 11
(Color Image Processing)

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Color Image Processing
Color Image Processing

- Full color processing: the images in question typically are acquired with full color sensor
- Pseudo-color processing: assigning a color to a particular monochrome intensity or range of intensities.
Pseudocolor Image processing

- Also Called false Image processing
- Definition: is the process of assigning color to monochrome image
- Advantage: Human can discern thousands of colors compared to one or two dozen shades of gray.
- Method: Intensity Slicing
Intensity Slicing

**Figure 6.18** Geometric interpretation of the intensity-slicing technique.
Intensity Slicing

- Multi level slicing (radiation image)

**FIGURE 6.20** (a) Monochrome image of the Picker Thyroid Phantom. (b) Result of density slicing into eight colors. (Courtesy of Dr. J. L. Blankenship, Instrumentation and Controls Division, Oak Ridge National Laboratory.)
Intensity Slicing

- Single level slicing (X-ray Weld image)

**FIGURE 6.21**
(a) Monochrome X-ray image of a weld. (b) Result of color coding. (Original image courtesy of X-TEK Systems, Ltd.)
Intensity Slicing

**FIGURE 6.22** (a) Gray-scale image in which intensity (in the lighter horizontal band shown) corresponds to average monthly rainfall. (b) Colors assigned to intensity values. (c) Color-coded image. (d) Zoom of the South America region. (Courtesy of NASA.)
Gray Level to color Transformation

**FIGURE 6.23** Functional block diagram for pseudocolor image processing. $f_R$, $f_G$, and $f_B$ are fed into the corresponding red, green, and blue inputs of an RGB color monitor.
Gray Level to color Transformation

FIGURE 6.24  Pseudocolor enhancement by using the gray-level to color transformations in Fig. 6.25. (Original image courtesy of Dr. Mike Hurwitz, Westinghouse.)
Gray Level to color Transformation

FIGURE 6.25 Transformation functions used to obtain the images in Fig. 6.24.
FIGURE 6.26 A pseudocolor coding approach used when several monochrome images are available.
FIGURE 6.27  (a)–(d) Images in bands 1–4 in Fig. 1.10 (see Table 1.1). (e) Color composite image obtained by treating (a), (b), and (c) as the red, green, blue components of an RGB image. (f) Image obtained in the same manner, but using in the red channel the near-infrared image in (d). (Original multispectral images courtesy of NASA.)
Pseudocolor processing using multiple monochrome images
Basics of Full color Image Processing

- Per-color-component based processing: each color is processed individually and then is combined to obtain processed image
- Vector based processing: each color pixel is interpreted as vector and processed individually.

\[
c(x, y) = \begin{bmatrix}
R(x, y) \\
G(x, y) \\
B(x, y)
\end{bmatrix}
= \begin{bmatrix}
c_R(x, y) \\
c_G(x, y) \\
c_B(x, y)
\end{bmatrix}
\]

- If the process are applicable to both scalar and vector and process on each component of vector be independent of other components two methods are equal
FIGURE 6.29
Spatial masks for gray-scale and RGB color images.
Color Transformation

- Gray level transformation

\[ g(x, y) = T[f(x, y)] \]

- Color transformation

\[ s_i = T_i[r_1, r_2, ..., r_n] \]
\[ i = 1, 2, ..., n \]
\[ n = 3 \quad \text{for } RGB \quad \text{model} \]
\[ n = 4 \quad \text{for } CMYK \quad \text{model} \]
Color Transformation

- Gray level function
  \[ g(x, y) = kf(x, y) \]

- RGB Space
  \[ s_i = kr_i \quad i = 1,2,3 \]

- HSI Space
  \[ s_3 = kr_3 \]

- CMY Space
  \[ s_i = kr_i + (1 - k) \quad i = 1,2,3 \]
Color Transformation

**FIGURE 6.30** A full-color image and its various color-space components. (Original image courtesy of MedData Interactive.)
FIGURE 6.31
Adjusting the intensity of an image using color transformations.
(a) Original image. (b) Result of decreasing its intensity by 30% (i.e., letting $k = 0.7$).
(c)–(e) The required RGB, CMY, and HSI transformation functions.
(Original image courtesy of MedData Interactive.)
FIGURE 6.32
Complements on the color circle.
Color Complement

FIGURE 6.33
Color complement transformations. (a) Original image. (b) Complement transformation functions. (c) Complement of (a) based on the RGB mapping functions. (d) An approximation of the RGB complement using HSI transformations.
Color Slicing

- Highlighting specific range of colors in an image

- **Method 1 (cubic area)**

\[
s_i = \begin{cases} 
0.5 & \text{if } \left| r_j - a_j \right| > \frac{W}{2} \text{ any } 1 \leq j \leq n \\
r_i & \text{otherwise}
\end{cases} \\
\text{i = 1, 2, \ldots, n}
\]

- **Method 2 (Spherical area)**

\[
s_i = \begin{cases} 
0.5 & \text{if } \sum_{j=1}^{n} (r_j - a_j)^2 > R_0^2 \\
r_i & \text{otherwise}
\end{cases} \\
\text{i = 1, 2, \ldots, n}
\]
FIGURE 6.34 Color slicing transformations that detect (a) reds within an RGB cube of width $W = 0.2549$ centered at $(0.6863, 0.1608, 0.1922)$, and (b) reds within an RGB sphere of radius 0.1765 centered at the same point. Pixels outside the cube and sphere were replaced by color $(0.5, 0.5, 0.5)$. 
Tone and Color Correction

- Tone Correction: adjusting brightness and contrast of the image experimentally
- methods
  1- changing I in HSI model
  2- mapping all colors of RGB or CMYK space with the same transformation
Figure 6.35  Tonal corrections for flat, light (high key), and dark (low key) color images. Adjusting the red, green, and blue components equally does not alter the image hues.
Color Correction

FIGURE 6.36 Color balancing corrections for CMYK color images.