Color Correction between Gray World and White Patch

- Color Constancy
- Color Correction Methods

Reference : A. Rizzi, C. Gatta, D. Marini. In Performance Evaluation of Signal And Image Processing Systems (2002). grp.

Color Constancy

正常光源影像

有色偏影像

Color Correction Methods

- 第一類: **Pixel Base**

  Gray World [1]

  Max RGB [2]

  White Patch

- 第二類: **Region Base**

  Retinex [3][4][5]

  Automatic Color Equalization(ACE)[6]

Pixel-Based

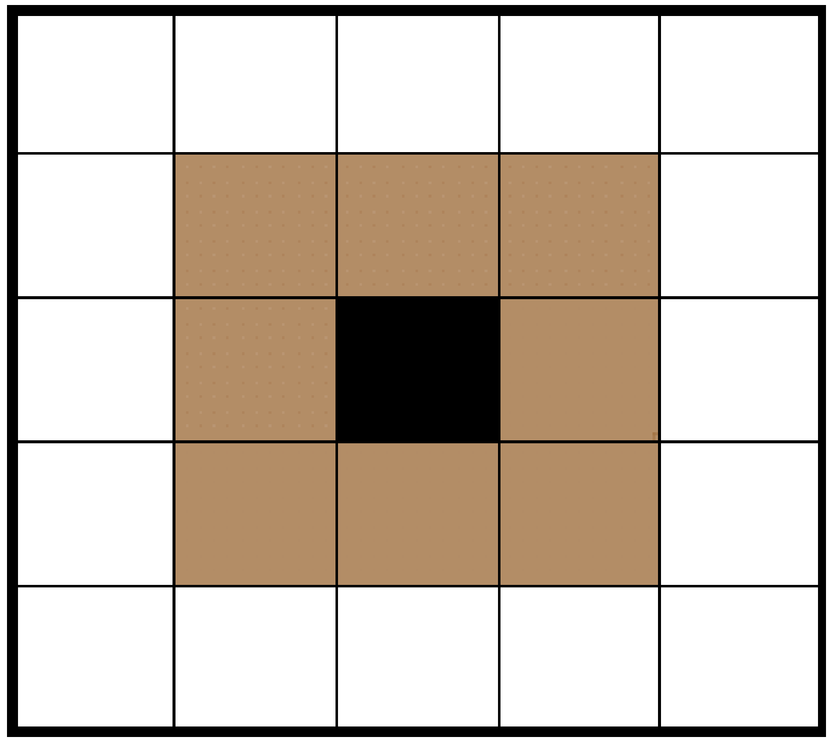
Von Kries色適應模式的轉換矩陣

$$\begin{bmatrix} R_a \\ G_a \\ B_a \end{bmatrix} = \begin{bmatrix} ScaleR & 0 & 0 \\ 0 & ScaleG & 0 \\ 0 & 0 & ScaleB \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

有色偏影像

正常光源影像

Region-Based



Pixel–Based Methods

- Gray World
- Max RGB
- White Patch

Gray World

- 理論假設:

RGB average = gray (R=G=B)

Gray World

- 演算法

  1.Computing average separately .

  $(R_{avg},\ G_{avg},\ B_{avg})$

  2. Reference Gray $= (R_{avg}+G_{avg}+B_{avg})/3$

  $= R'_{avg}$

  $= G'_{avg}$

  $= B'_{avg}$

Gray World

- $ScaleR = R'_{avg} \ / \ R_{avg}$
- $ScaleG = G'_{avg} \ / \ G_{avg}$
- $ScaleB = B'_{avg} \ / \ B_{avg}$

Gray World

- 轉換

$$\begin{bmatrix} R_a \\ G_a \\ B_a \end{bmatrix} = \begin{bmatrix} ScaleR & 0 & 0 \\ 0 & ScaleG & 0 \\ 0 & 0 & ScaleB \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

Von Kries

Pixel–Based Methods

- Gray World
- Max RGB
- White Patch

Max RGB

- 演算法:

  1. Finding maximal value separately.

     (R_{max} , G_{max} , B_{max})

  2. Reference White=(255,255,255)

Max RGB

- $ScaleR = R_{max} / 255$
- $ScaleG = G_{max} / 255$
- $ScaleB = B_{max} / 255$

Max RGB

- 轉換

$$\begin{bmatrix} R_a \\ G_a \\ B_a \end{bmatrix} = \begin{bmatrix} ScaleR & 0 & 0 \\ 0 & ScaleG & 0 \\ 0 & 0 & ScaleB \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

Pixel–Based Methods

- Gray World
- Max RGB
- White Patch

White Patch

- 演算法:

  1. Finding maximal pixel on R+G+B (R_p, G_p , B_p)

  2. Reference White=(255,255,255)

White Patch

- ScaleR $= R_p / 255$
- ScaleG $= G_p / 255$
- ScaleB $= B_p / 255$

White Patch

- 轉換

$$\begin{bmatrix} R_a \\ G_a \\ B_a \end{bmatrix} = \begin{bmatrix} ScaleR & 0 & 0 \\ 0 & ScaleG & 0 \\ 0 & 0 & ScaleB \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

Region–Based Methods

- Retinex
- Automatic Color Equalization(ACE)

Retinex

- 理論: 物體間的明亮度是相對的.
- 灰階: 單一channel明亮度調整
- 色彩: 三個channel明亮度調整(R, G, B)

Retinex

$$I'(x_i) = I(x_i) + \log(\rho^{x_i}) - \log(\rho^{x_j})$$

X_i: 目前像素

X_j: 鄰近像素

$I(x_i)$: 目前像素值

$I'(x_i)$: 計算完後的像素值

$\log(\rho^{x_i})$: 目前像素值的亮度

$\log(\rho^{x_j})$: 周圍像素值的亮度

Retinex

- 演算法基本概念: $L = E \cdot R$

L:人眼感知的強度
E:代表環境光源強度
R:代表物體表面反射率

Retinex

- 光源 ： 低頻部分
- 被照射物體 : 高頻部分

可以用低通濾波大概取出光源部分

Retinex

$$\log(L)= \log(E)+\log(R)$$

$$\log(R)=\log(L)-\log(E)$$

Log(R)即為物體未受光源照射的樣子

Retinex

- 演算法:

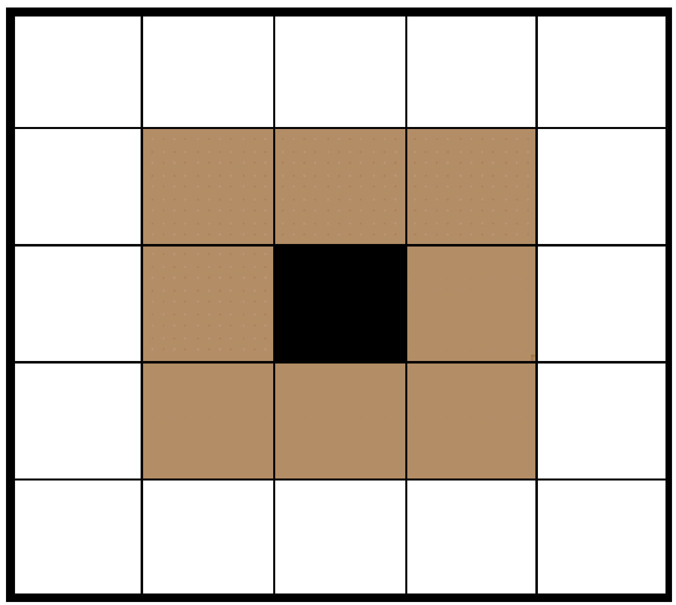
  1. SSR (single scale Retinex)
  2. MSR(multi-scale Retinex)
  3. MSRCR (multi-scale Retinex with color restoration)

Retinex

- SSR，MSR -- 計算灰階影像物體間相對的明度
- MSRCR --計算彩色影像物體間R,G,B相對的彩度

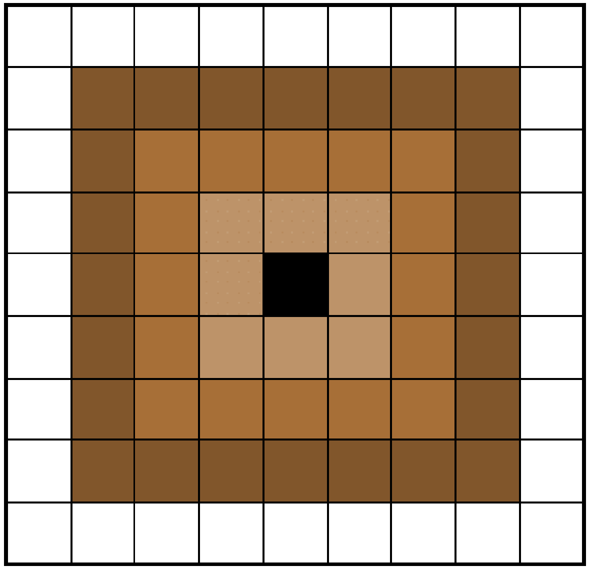
Retinex

- SSR (single scale Retinex)-單一濾波



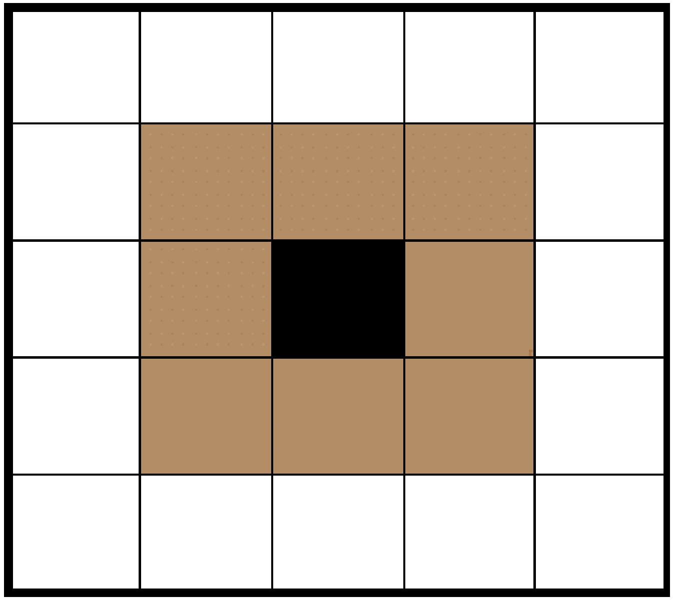
Retinex

- MSR(multi-scale Retinex)-多個濾波



Retinex-SSR

- 示意圖:



Retinex-SSR

$$R(x,y) = \log I(x,y) - \log[F(x,y) * I(x,y)]$$

$$F(x,y) = Ke^{\frac{-(x^2+y^2)}{c^2}}$$

c 值影響影像輸出結果

$$\iint F(x,y)dxdy = 1$$

Retinex-SSR

- C值↑ : 包含較多Pixel ，保留較多資訊
- C值↓ : 包含較少Pixel ，保留較少資訊

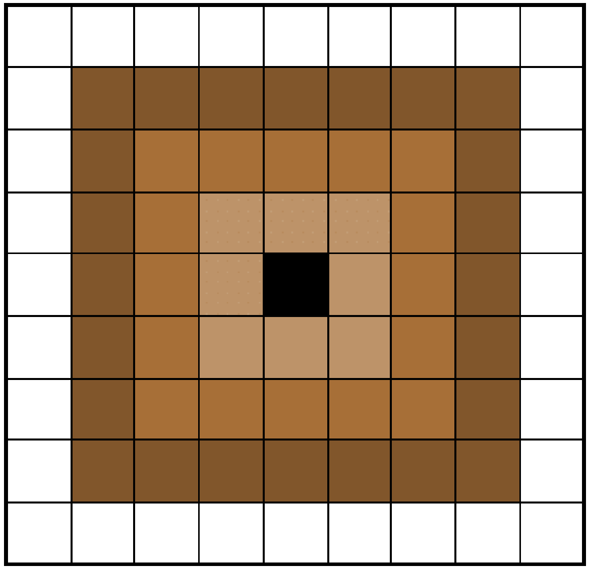
原圖

C = 2

C = 150

Retinex-MSR

- 示意圖:



- 三個不同的顏色區域，代表著3 個不同大小的高斯函數

Retinex-MSR

$$R(x,y)=\sum_{k=1}^{K} W_k(\log I(x,y)-\log[F(x,y)*I(x,y)])$$

Wk:權重值 (Sum=1)

Retinex-MSR




Retinex-MSRCR

$$R'_{MSR_i}(x,y) = \mathrm{R}_{\mathrm{MSR_i}}(x,y) \times I'_i(x,y)$$

$$I'_i(x,y) = \beta \log(\alpha \frac{I_i(x,y)}{\sum_{i=1}^{3} I_i(x,y)})$$

Retinex-MSRCR

原始影像

SSR

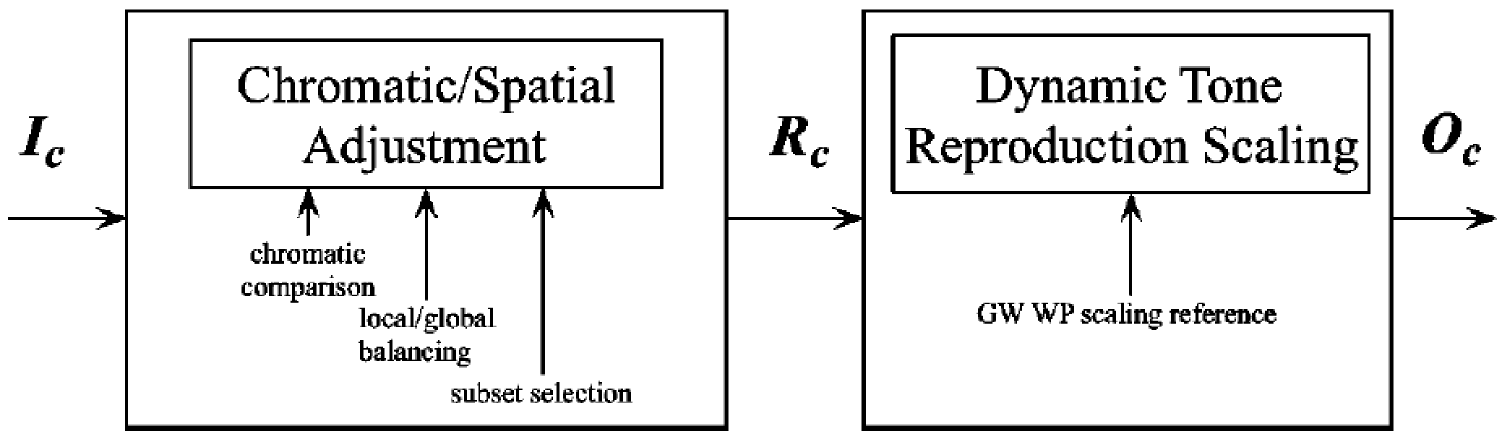
MSR

MSRCR

Region–Based Methods

- Retinex
- Automatic Color Equalization(ACE)

ACE



step1

step2

I_c : 輸入影像

R_c : step1 計算完後的影像

O_c : 最後結果

ACE-step1

◆ Chromatic spatial adjustment

– Algorithm

$$R_C(p) = \sum_{j \in \text{Image}, j \neq p} \frac{r[I_c(p) - I_c(j)]}{d(p, j)}$$

- $r(\cdot)$ function influences the white patch behavior and contrast
- $d(\cdot)$ function include the concept of spatial influence
- $I_c(p) - I_c(j)$ accounts for the lateral inhibition mechanism
- $r(\cdot)$ function

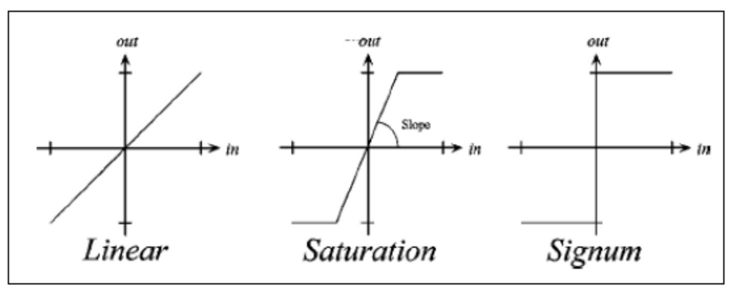


Fig. 4. $r(\cdot)$ function set

ACE-step1

– Filtered sampled images with different $r(\cdot)$ function

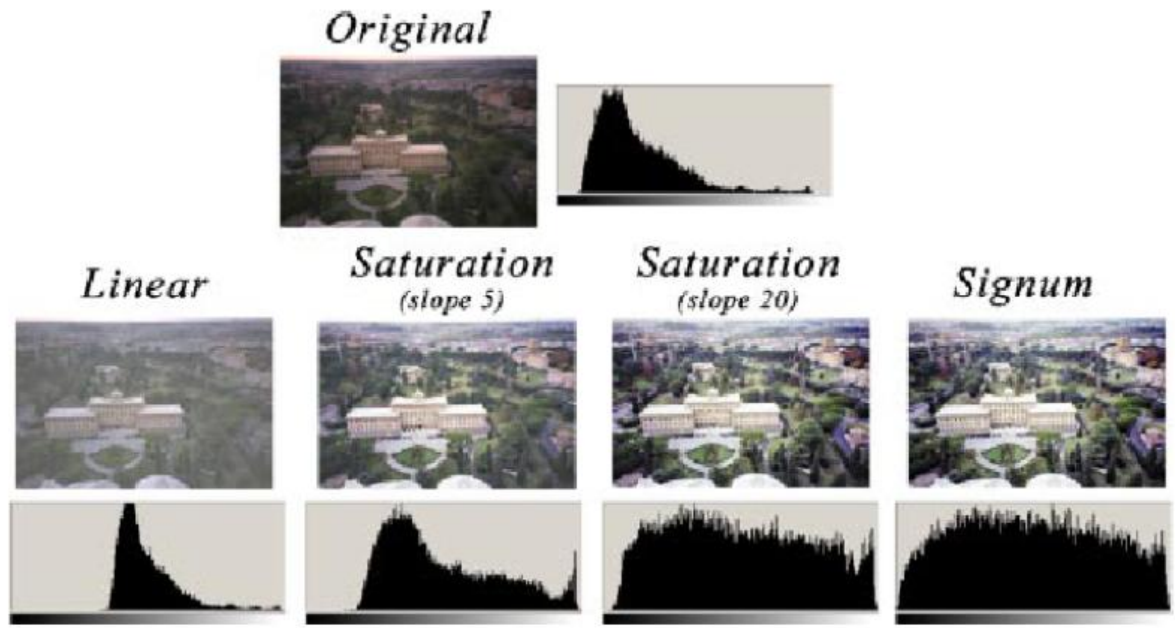
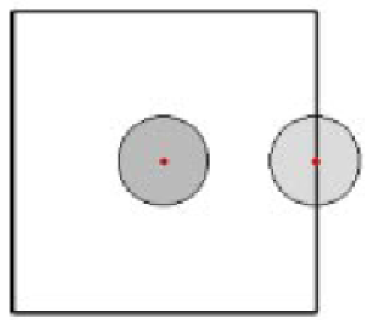


Fig. 5. Sampled images (after the dynamic tone reproduction scaling stage)

ACE-step1 Problem

- The pixel from the picture margin
  - The number of pixel near it decrease significatively



  - Modified with a normalization coefficient

$$R_C(p) = \frac{\displaystyle\sum_{j \in \text{Image}, j \neq p} \frac{r[I_c(p) - I_c(j)]}{d(p,j)}}{\displaystyle\sum_{j \in \text{Image}, j \neq p} \frac{r_{\max}}{d(p,j)}}$$

ACE-step2

- Tone reproduction
  - To map this range into the (0,255)
  - Linearly scales the values in R_C

$$O_C(p) = \text{round}[127.5 + s_c R_c(p)]$$

where p : each pixel

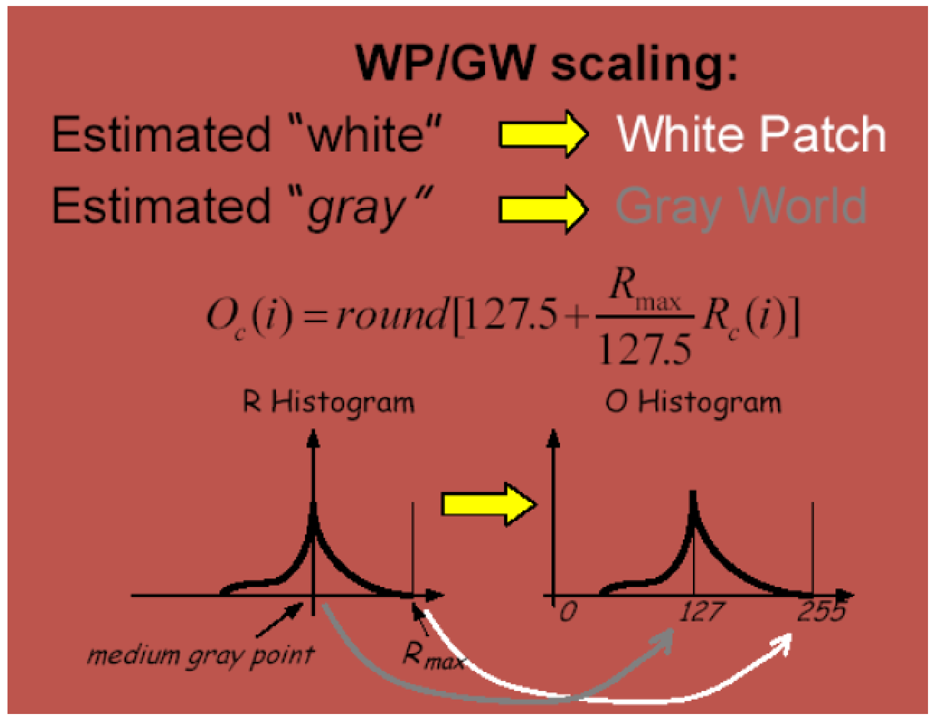
s_c : slope of the segment $[(0,127.5),(M_c,255)]$

$$s_c = \frac{M_c - 0}{255 - 127.5} = \frac{M_c}{127.5}$$

$M_c : \max_p R_c(p)$

ACE-step2

– Global balance between gray world and white patch



ACE-result

(a) 輸入影像

(b) ACE 處理結果

Reference

- [1]徐晓昭, 蔡轶珩, 刘晓民, 刘长江, 沈兰荪, ”改进灰度世界颜色校正算法”, Vol.39 No.3 March2010.
- [2]雲如臨,陳雨柔, “影像的色偏校正”,臺灣二○○八年國際科學展覽會.
- [3] D. H. Brainard and B. A. Wandell, “Analysis of the retinex theory of color vision”, Vol. 3, No. 10/October 1986/J. Opt. Soc. Am. A
- [4]洪念祖, “基於區域適應和敵對色彩對比強化的影像調整及色彩平衡方法”, 逢甲大學通訊工程學系碩士班碩士論文.
- [5]盧俊良, “基於光線與臉部表情變化下之人臉辨識”,國立中央大學資訊工程研究所碩士論文.
- [6] A. Rizzi, C. Gatta, and D. Marini, “From Retinex to automatic color equalization: issues in developing a new algorithm for unsupervised color equalization,” *Journal of Electronic Imaging*, vol. 13, no. 1, pp. 75-84, 2004.