Color Transfer between Images

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The original paper

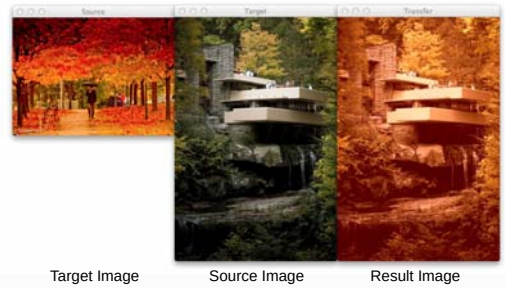
- E. Reinhard, M. Ashikhmin, B. Gooch, and P. Shirley, "Color transfer between images," *IEEE Computer Graphics and Applications*, vol. 21, no. 5, pp. 34-41, September/October 2001.
- Four authors:
  - First author: E. Reinhard
- Co-authors: three co-authors
  - M. Ashikhmin, B. Gooch, P. Shirley
- Corresponding author:
  - If not mention, usually the first author is also the corresponding author
- See the paper PDF

Color Transfer

- One of tasks for image processing: altering an image's color
- Goal of this paper
  - Describing a method that borrows one image's color characteristics from another
  - Source image: the original (standard image)
  - Target image: the colors of an image intends to be altered

source target Result

Example



Target Image Source Image Result Image

http://www.pyimagesearch.com/2014/06/30/super-fast-color-transfer-images/

Basic RGB Color Transfer Algorithm: 3 Steps

- A **three** steps approaches with two images, the source and the target image
- Input: Source image (MxN), Target image (UxV)
- Output: result image (MxN)
- Step 1:
  - Determining mean (m), standard deviation (d) values of the source image
  - Determining mean, standard deviation of the target image
- Step 2: Statistical pixel processing using eq. 1
  - Note: we repeat step 2 until all of the pixels (MxN) in the source image are processed
- Step 3: Pixel Validation: make sure that pixel values are within the valid range

Step 1

- Determining mean, variance values of the source image
- How to derive mean and standard deviation?

Mean and Standard Deviation

- Mean and Standard Deviation

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2}, \quad \text{where} \quad \mu = \frac{1}{N}\sum_{i=1}^{N} x_i.$$

- Example: considering the following 8 values

$$2,\ 4,\ 4,\ 4,\ 5,\ 5,\ 7,\ 9.$$

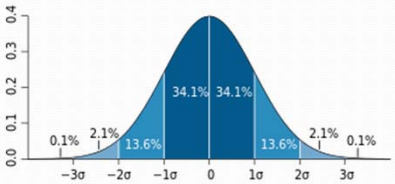
- Mean is 5 since $\frac{2+4+4+4+5+5+7+9}{8} = 5.$

$$\begin{array}{ll} (2-5)^2 = (-3)^2 = 9 & (5-5)^2 = 0^2 = 0 \\ (4-5)^2 = (-1)^2 = 1 & (5-5)^2 = 0^2 = 0 \\ (4-5)^2 = (-1)^2 = 1 & (7-5)^2 = 2^2 = 4 \\ (4-5)^2 = (-1)^2 = 1 & (9-5)^2 = 4^2 = 16. \end{array}$$

- Standard deviation is 2 since $\sqrt{\frac{9+1+1+1+0+0+4+16}{8}} = 2.$

Standard Deviation (SD) (σ)

- a measure used to **quantify** the amount of variation (變化程度)or dispersion (偏差) of a set of data values
- σ is near 0 indicating that the data points tend to be very close to the mean



A plot of a normal distribution (or bell-shaped curve) where each band has a width of 1 standard deviation
Rule: 68.2-95.4-99.7

http://en.wikipedia.org/wiki/Standard_deviation

- After Step 1 we produce 12 values
- Source image: three channels r, g, b
  - RGB mean values: mr_s, mg_s, mb_s
  - RGB standard deviation values: dr_s, dg_s, db_s
- Target image: three channels r, g, b
  - RGB mean values mr_t, mg_t, mb_t
  - RGB standard deviation values: dr_t, dg_t, db_t

Step 2: Statistical pixel processing

$$R(x,y) = \frac{d_t}{d_s}[S(x,y) - m_s] + m_t \qquad \text{Eq. 1}$$

R(x, y): pixel (x, y) in the result image

S(x, y): pixel (x, y) in the source image

d_t: standard deviation in the target image

d_s: standard deviation in the source image

m_s: mean in the source image

m_t: mean in the target image

Step 3: Pixel Validation

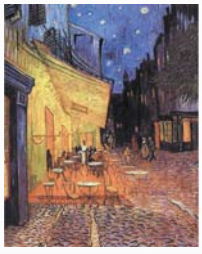
- We need to derive an integer representation after pixel processing.
- Use Floor function to derive an integer that is close to the floating value
- Make sure the pixel value is within [0, 255]

$$R(x,y) = \left\lfloor \frac{d_t}{d_s}[S(x,y) - m_s] + m_t + 0.5 \right\rfloor$$

Source Image

Target Image

Result Image



Target Image

Source Image

Result Image

Third Assignment

- Implement the RGB color transfer algorithm
- Deadline: 3/11 23:30
- Submit: 6 pairs of color transfer results
- We provide the Kodak database which can be used for cases 1, 2, 3, and 4
- Cases 5, 6: you find your own images
- Source images: s1, s2, s3, s4, s5, s6 (>=512x 512)
- Target images: t1, t2, t3, t4, t5, t6 (>= 512x 512)
- Result images: tr1, tr2, tr3, tr4, tr5, tr6
- Kodak image database: you need to transfer them to the bmp format
- You can use fsview for batch transfer
- http://rok.us/graphics/kodak/