A method determining tone conversion characteristics of digital still camera from two pictorial images

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Tone conversion characteristics

Tone conversion characteristics of a digital still camera

→ one of the most important characteristics

→ used for the transformation of raw red, green and blue digital values, R, G and B, to colorimetric values X, Y and Z

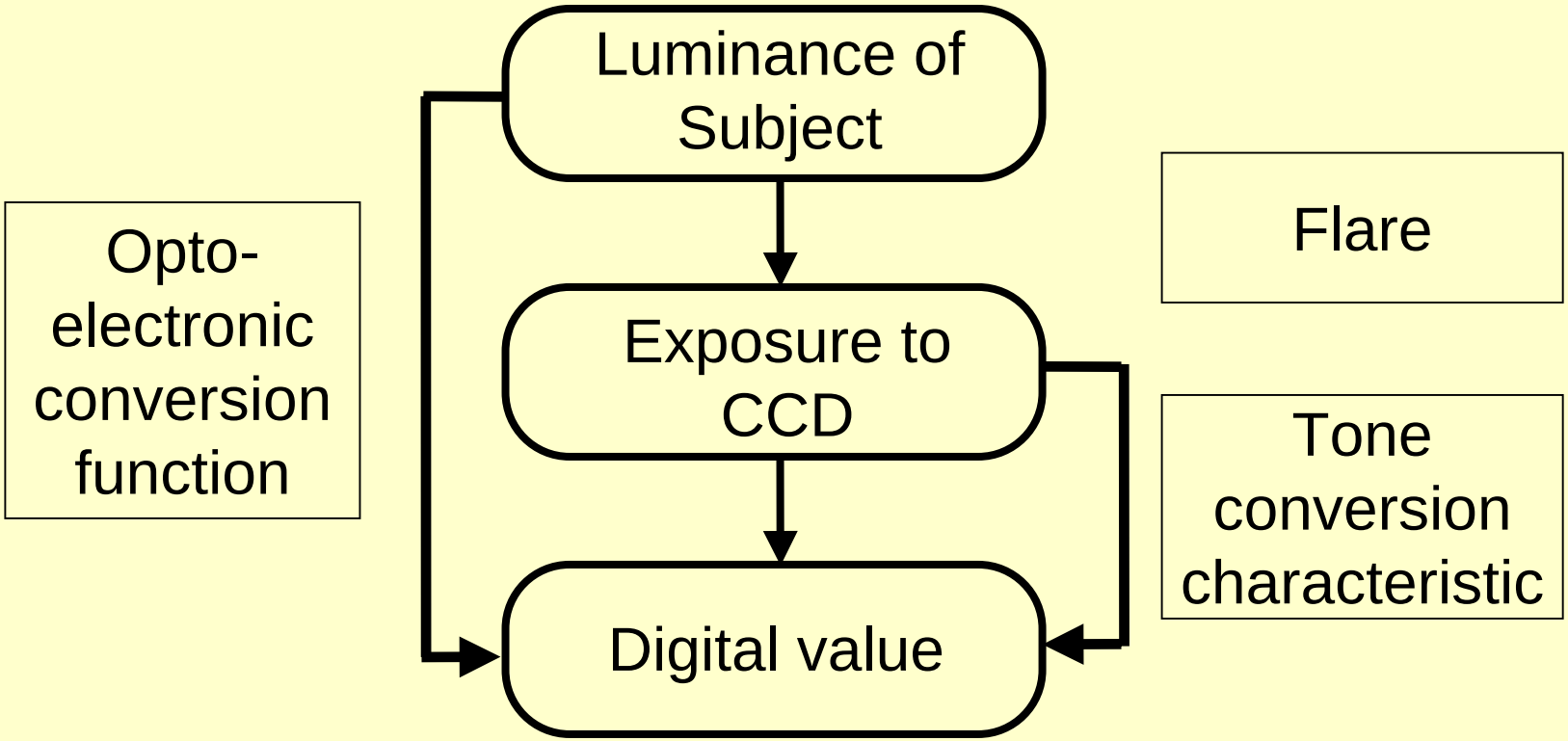
Also called

"characteristic curve" in photography

"gamma characteristic" in television

"opto-electronic conversion function (OECF)" in digital still camera defined in ISO 14524

Tone conversion characteristic

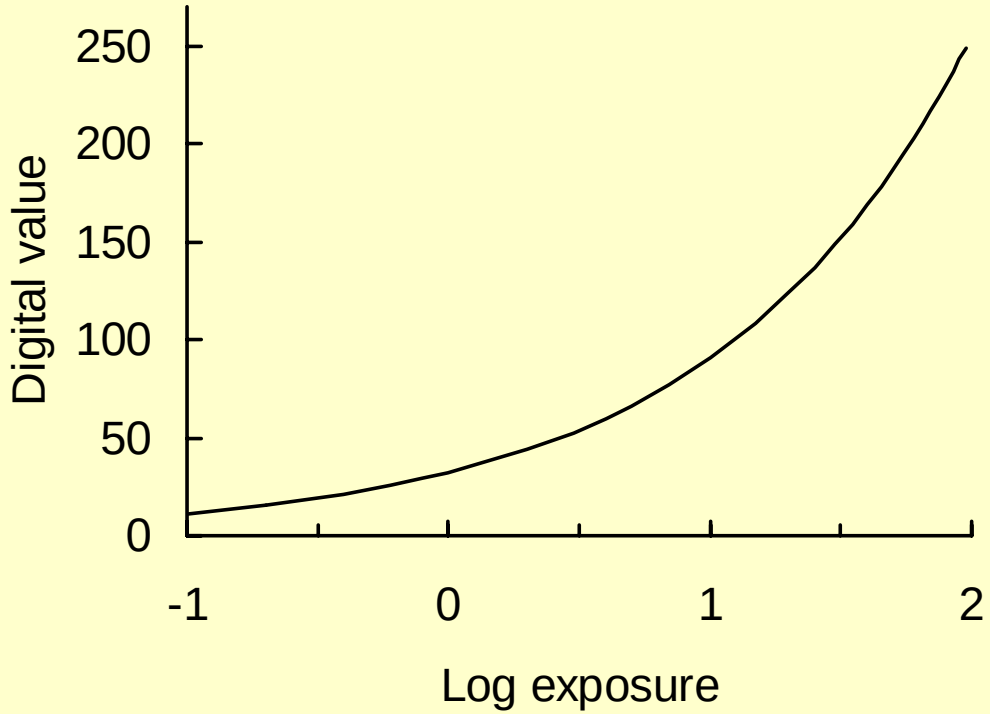


Different x-axis for two types

Y-axis

→ Digital value

R,G or B



X-axis

→ Exposure to CCD, or illumination on imaging plane

→ Scene luminance, or reflectance of subject

Measurement with a gray scale

Problems

- few patches
- non-uniform illumination
- decrease of surrounding illumination
- effects of flare

A new method to obtain tone conversion characteristics

- Conventional method

  X-axis is density or reflectance of a gray scale patches.

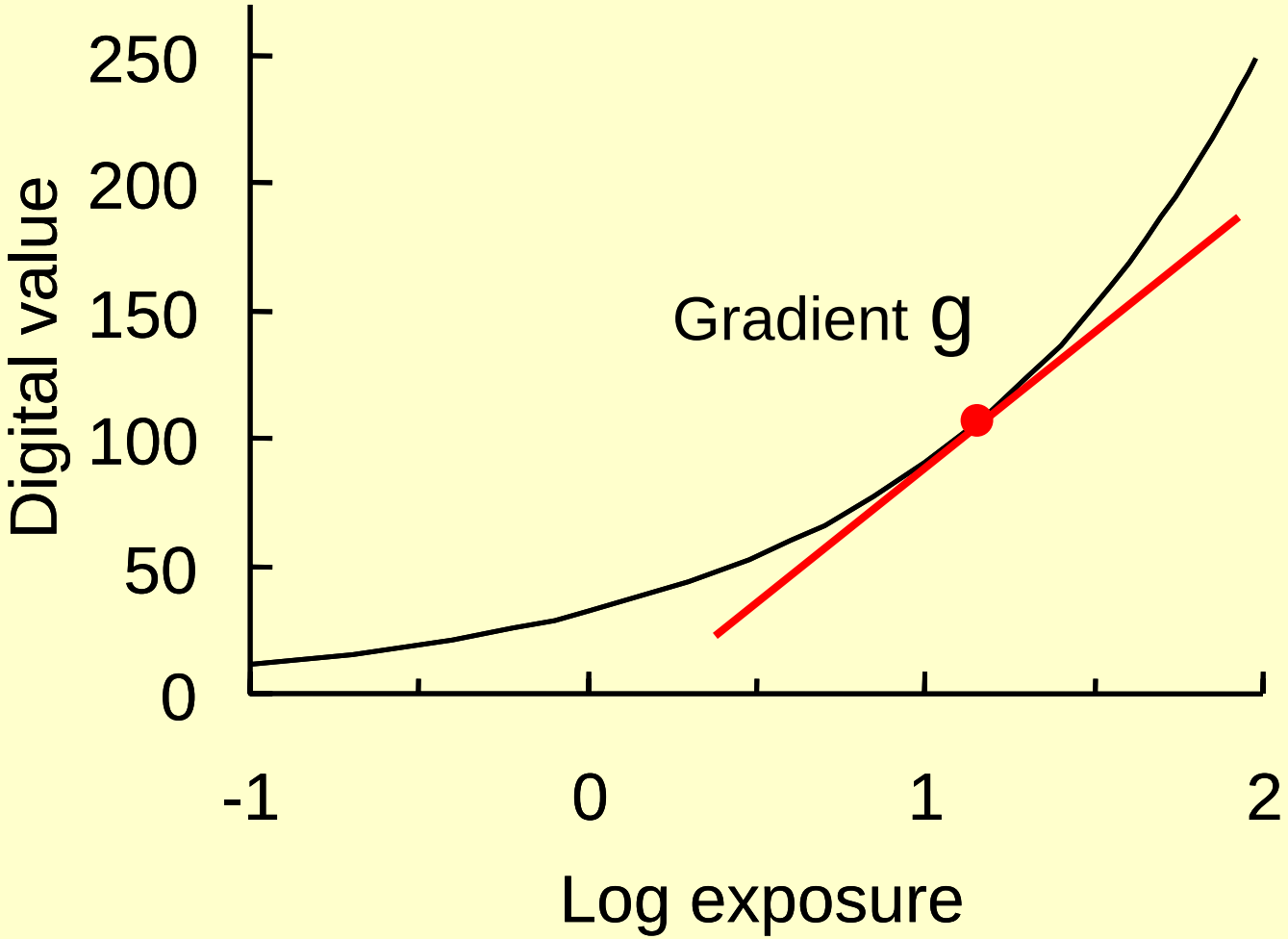
  Gray scale is necessary.

- New method

  X-axis is calculated from two pictorial images with different exposure.

  Gray scale is unnecessary.

Gradient of tone conversion characteristics



Method of determining tone conversion characteristics

$$g = \frac{\mathrm{d}\, D}{\mathrm{d} \log H} \qquad (1)$$

$$\log H = \int \frac{\mathrm{d}\, D}{g} + C \qquad (2)$$

Two stepwise images with different exposure

Subject

i

Image 1

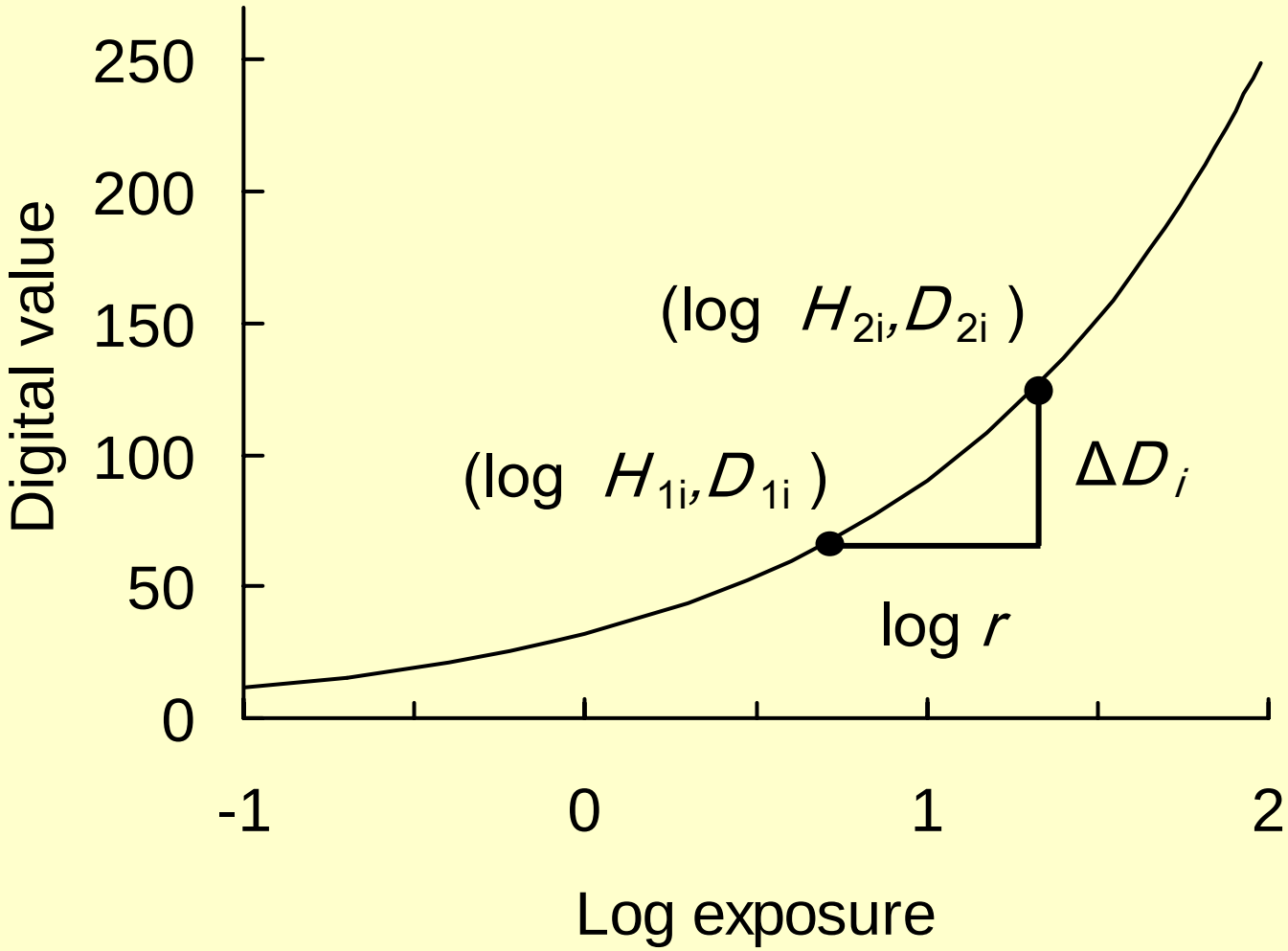
D_{1i}

Exposure ratio r

Image 2

D_{2i}

Tone conversion characteristic curve and variables used in this study



$$H_{2i} = r\, H_{1i} \qquad (3)$$

$$(i = 1,2,3,---,n)$$

$$\overline{g}_i = \frac{D_{2i} - D_{1i}}{\log r} \qquad (4)$$

$$D_i = \frac{w_{1i} D_{1i} + w_{2i} D_{2i}}{w_{1i} + w_{2i}} \qquad (5)$$

$$w_{1i} = 2\Delta D_{1i} + \Delta D_{2i} \qquad (6)$$

$$w_{2i} = \Delta D_{1i} + 2\Delta D_{2i} \qquad (7)$$

$$\log H_i = \log H_{i-1} + \frac{D_i - D_{i-1}}{\bar{g}_i} \qquad (8)$$

The tone conversion characteristics can be calculated

from the set of digital values from Eq. (5) and the log exposure from Eq. (8).

Application to pictorial image

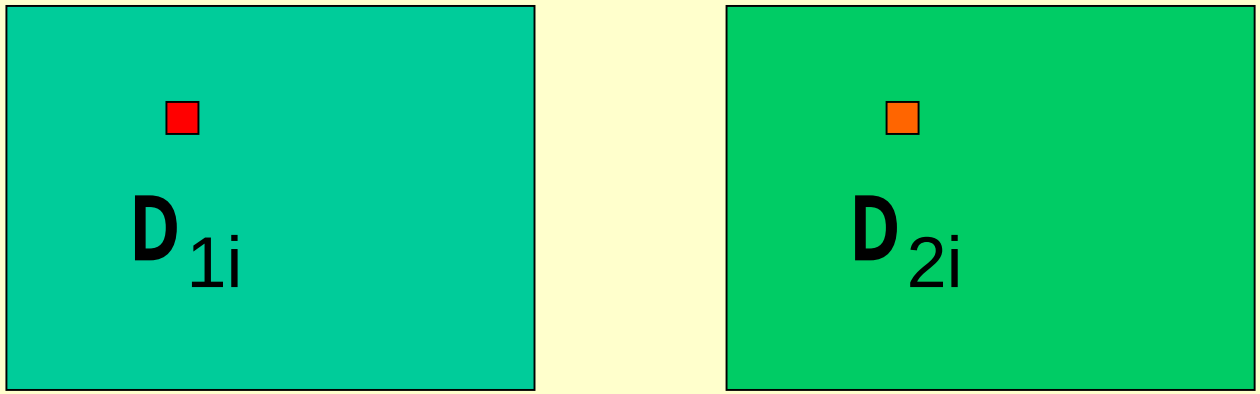
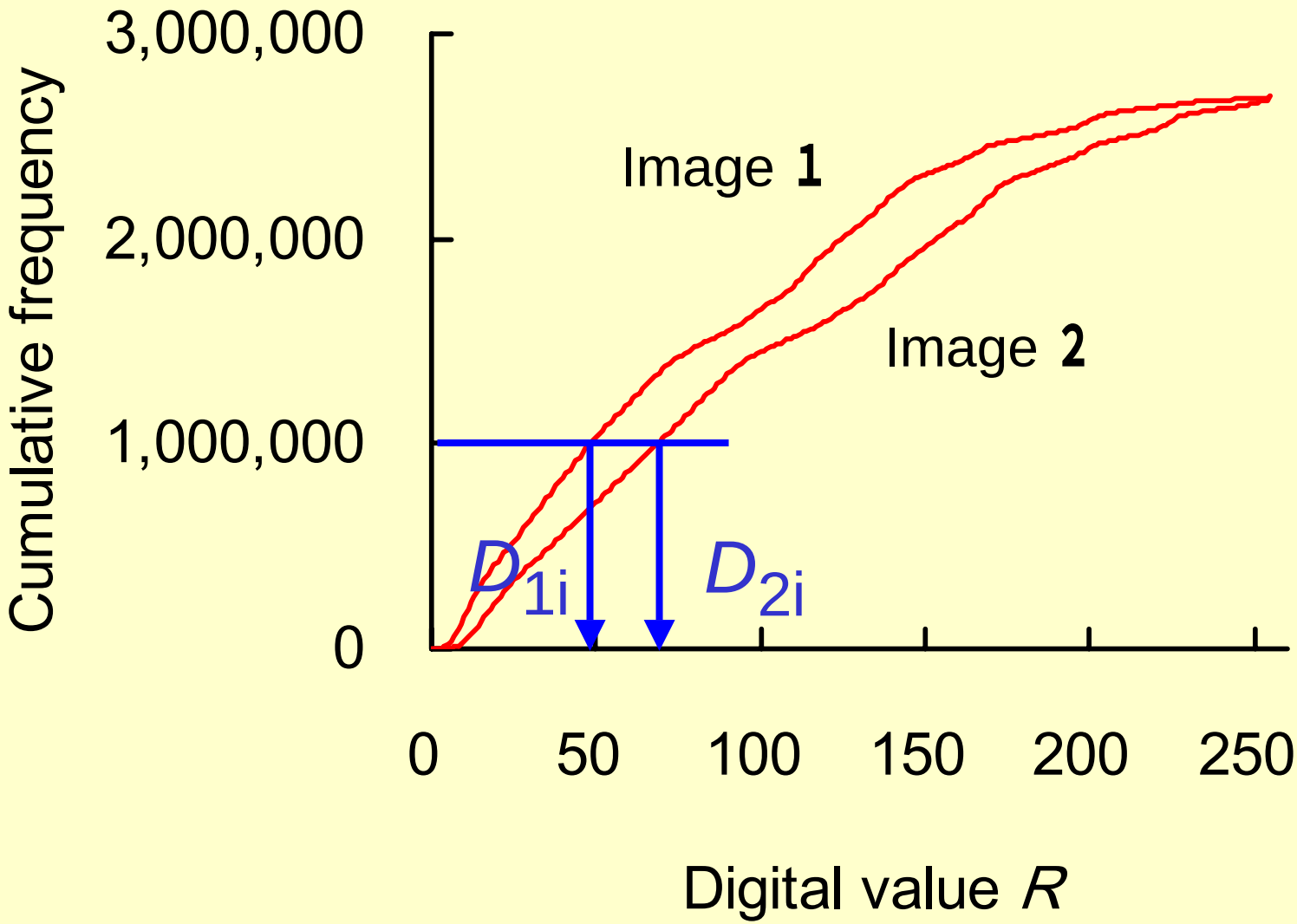


Image 1 Image 2

Digital values pair determined from corresponding pixels

→ Several million pairs, containing noise

Determining digital value pairs from cumulative frequency



Calculation steps for pictorial images

(1) cumulative frequency distributions of two images are calculated,

(2) corresponding digital values of two images, D_{1i} and D_{2i} (i = 1,2,---,n), for the same cumulative frequency are determined,

(3) digital values D_i between D_{1i} and D_{2i} are calculated as a weighted average,

(4) the log relative exposure, log H_i, is integrated from digital values D_{1i} and D_{2i}.

Image capture

Minolta Dimage RD-3000 digital still camera

Different exposure time

Full open diaphragm

Indoors with tungsten lamps

Two images used in this study

Image 1

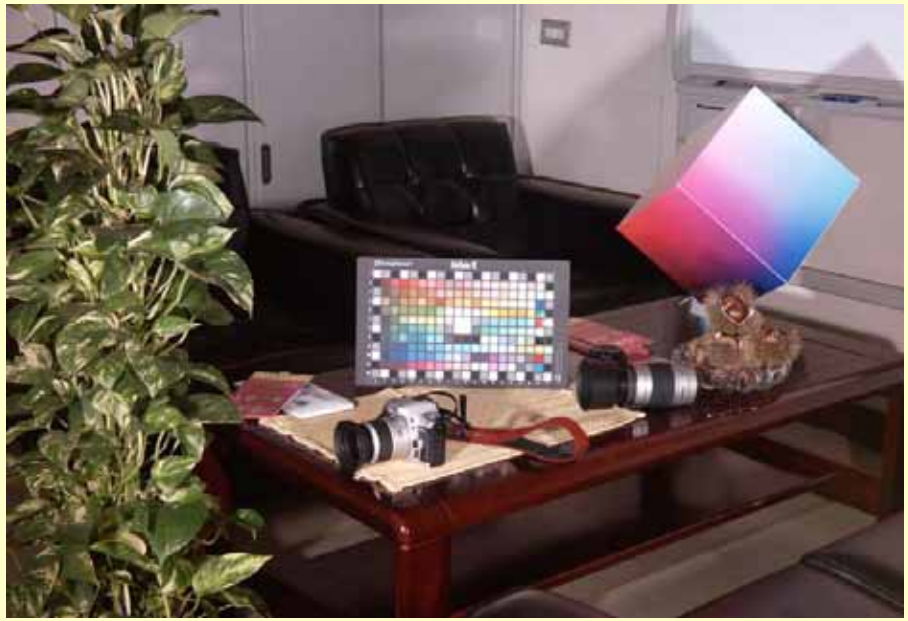
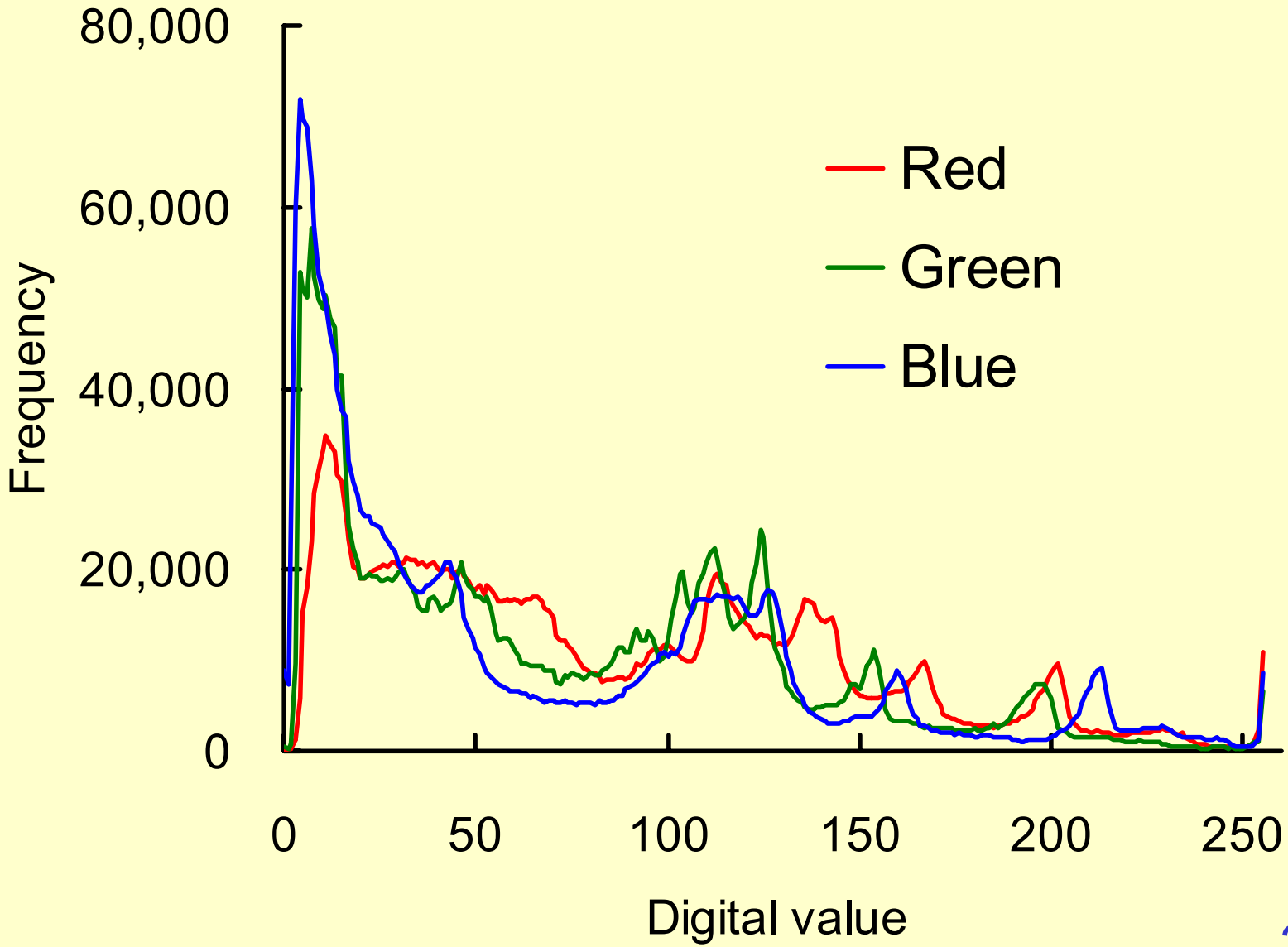
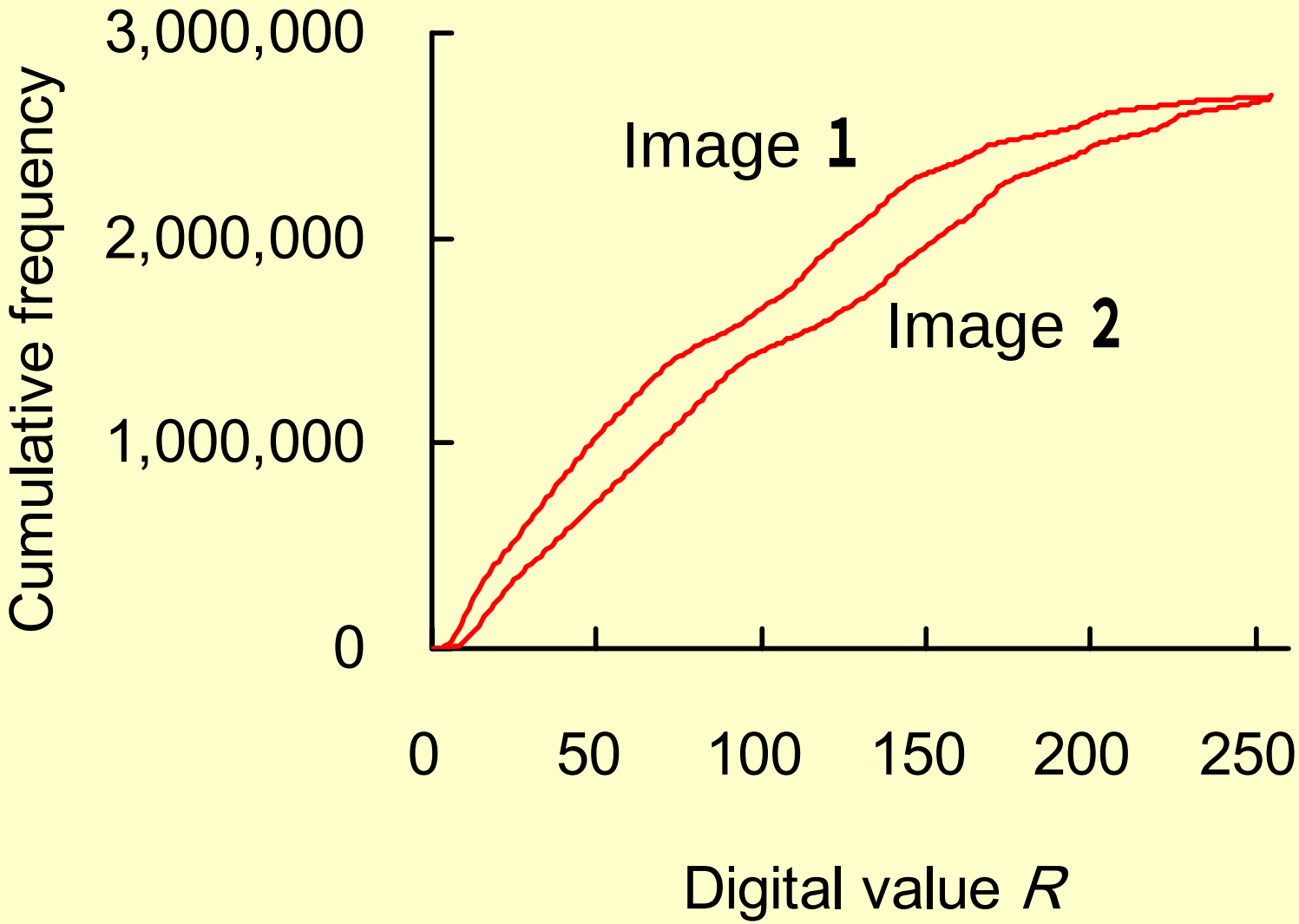


Image 2

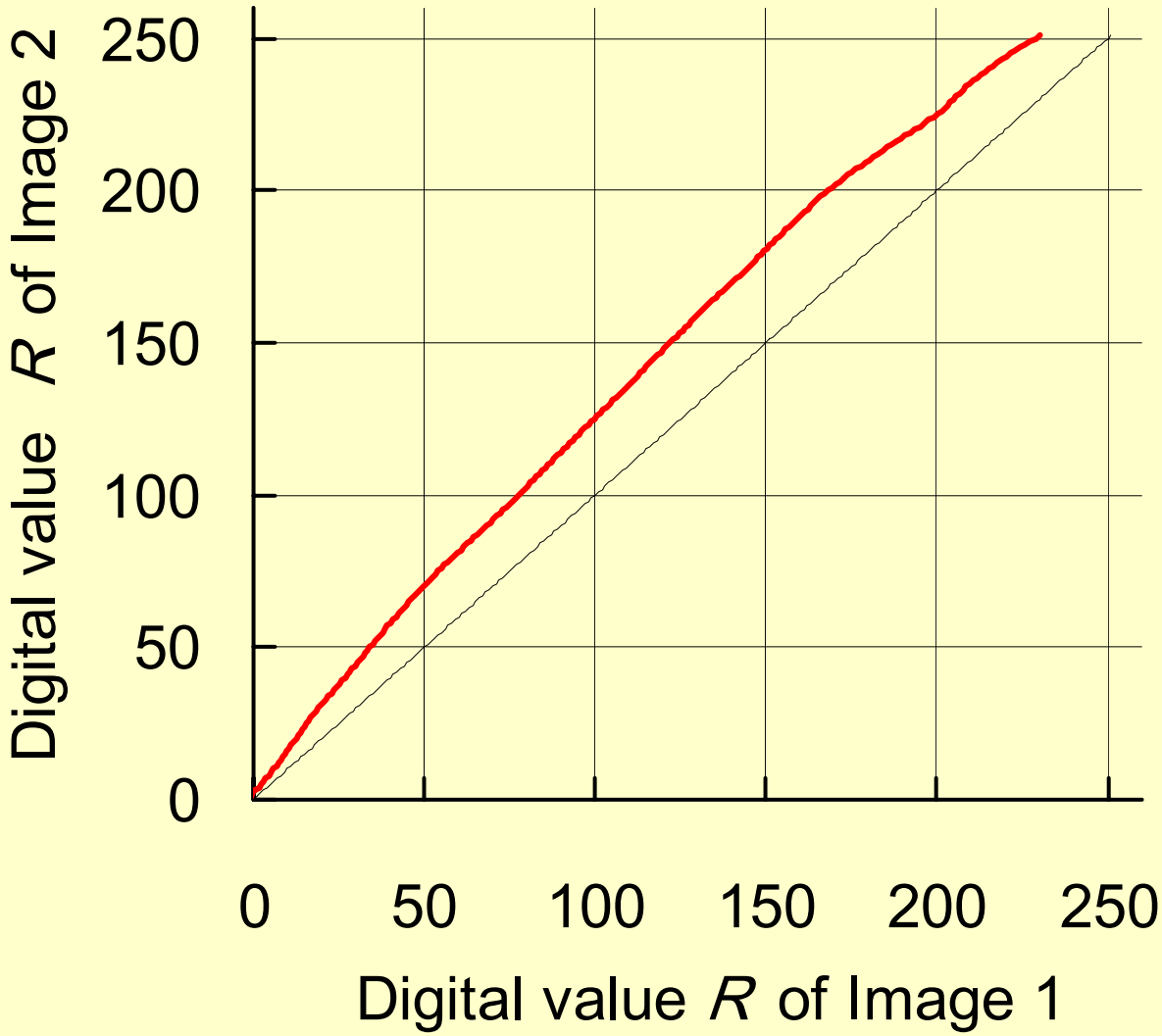
Histogram of Image 1



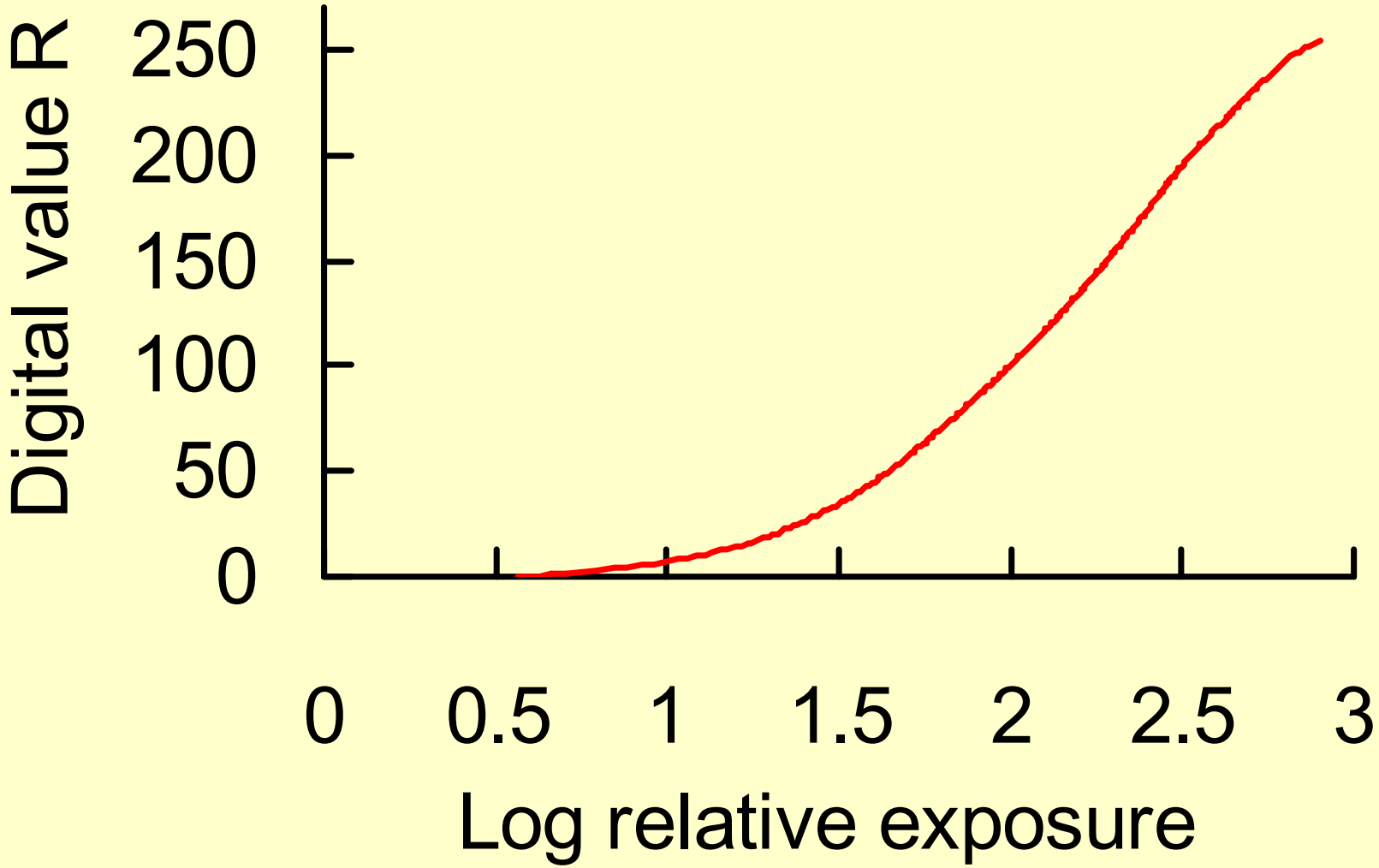
Cumulative frequencies of digital value *R*



Digital value pair D_{1i} and D_{2i}



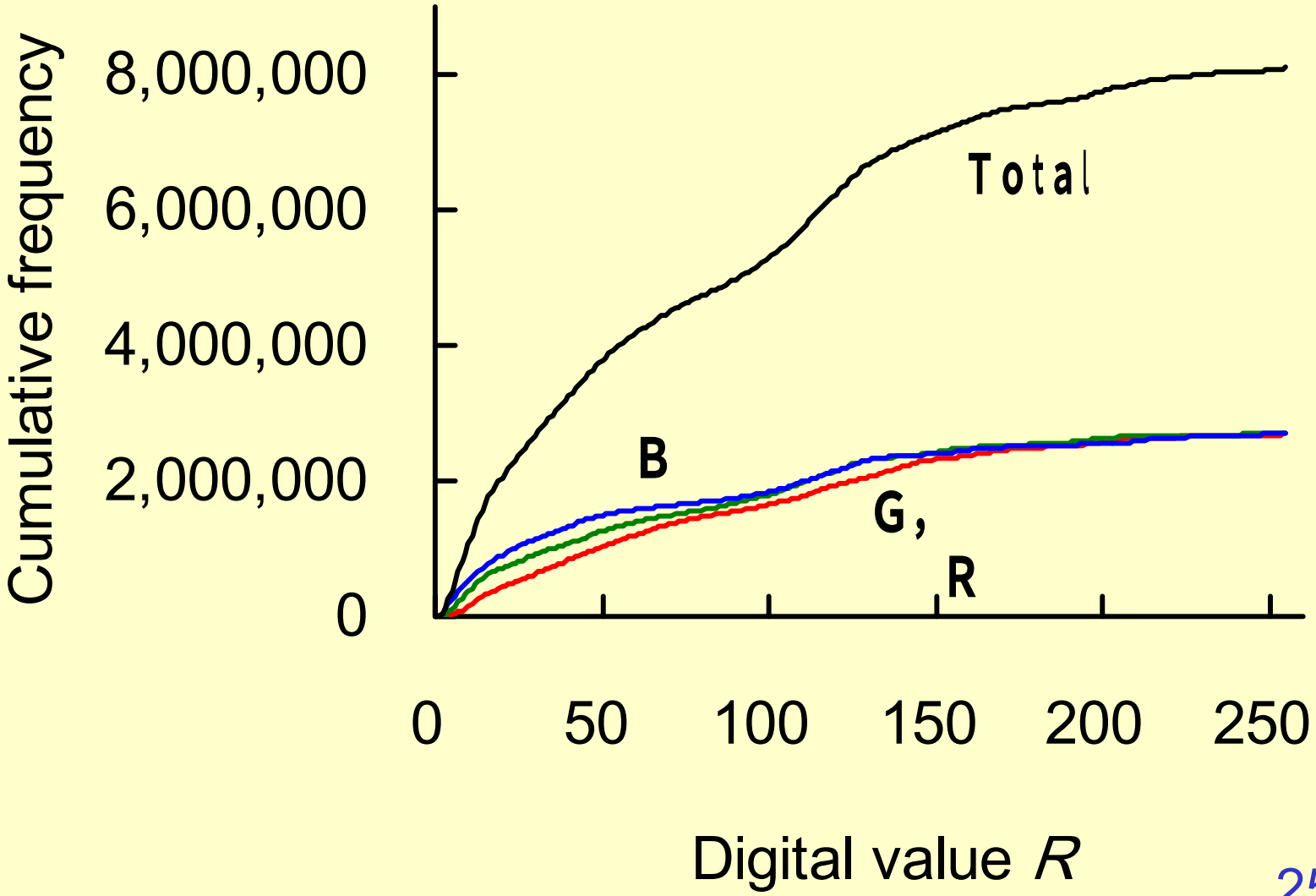
Calculated tone conversion characteristics for digital values *R*



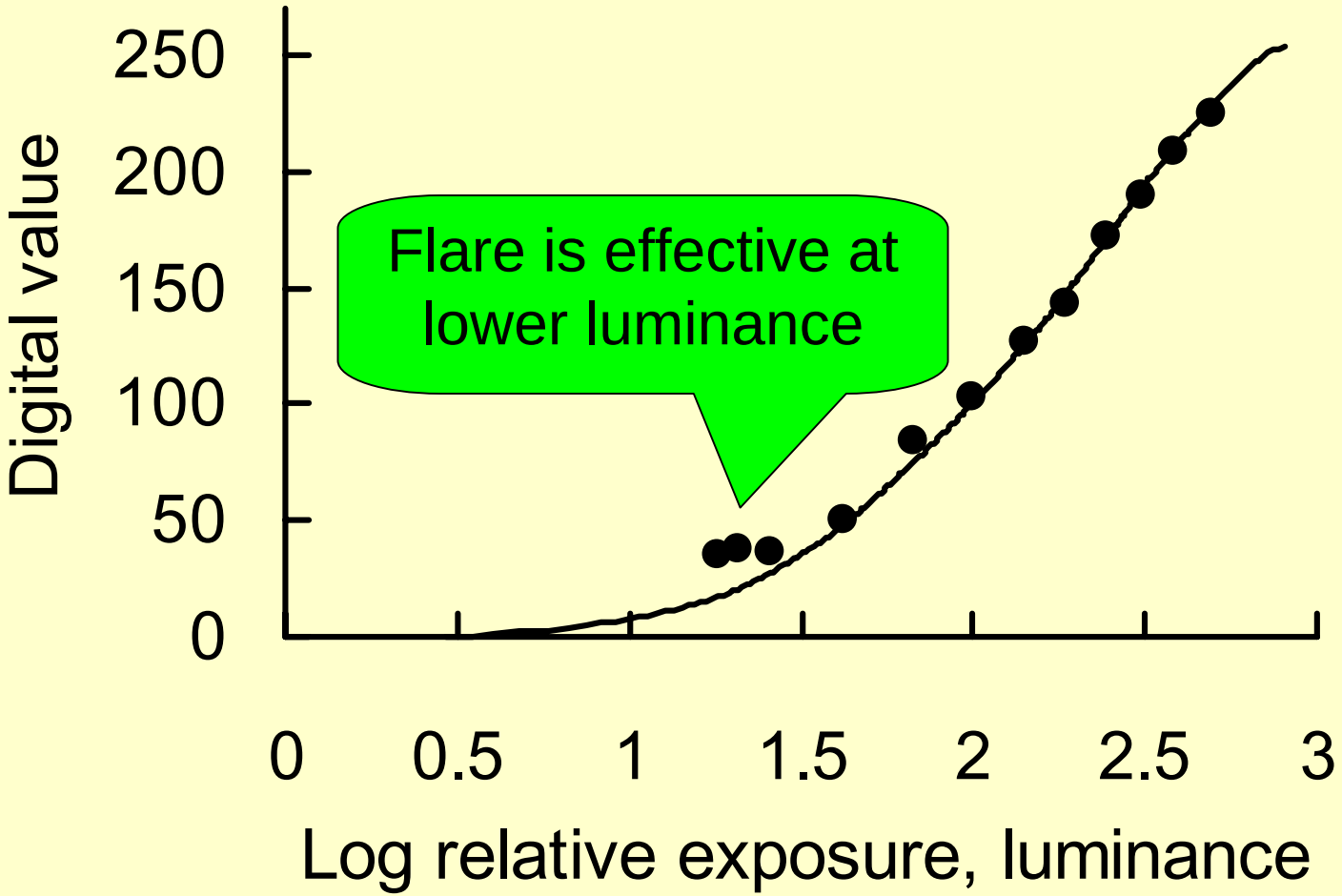
Calculated tone conversion characteristics for three color digital values

- Calculated tone conversion characteristics for three color digital values are almost identical
- Total cumulative frequency by adding three color digital values is used to computation
- Calculated tone conversion characteristics for total digital values is average one

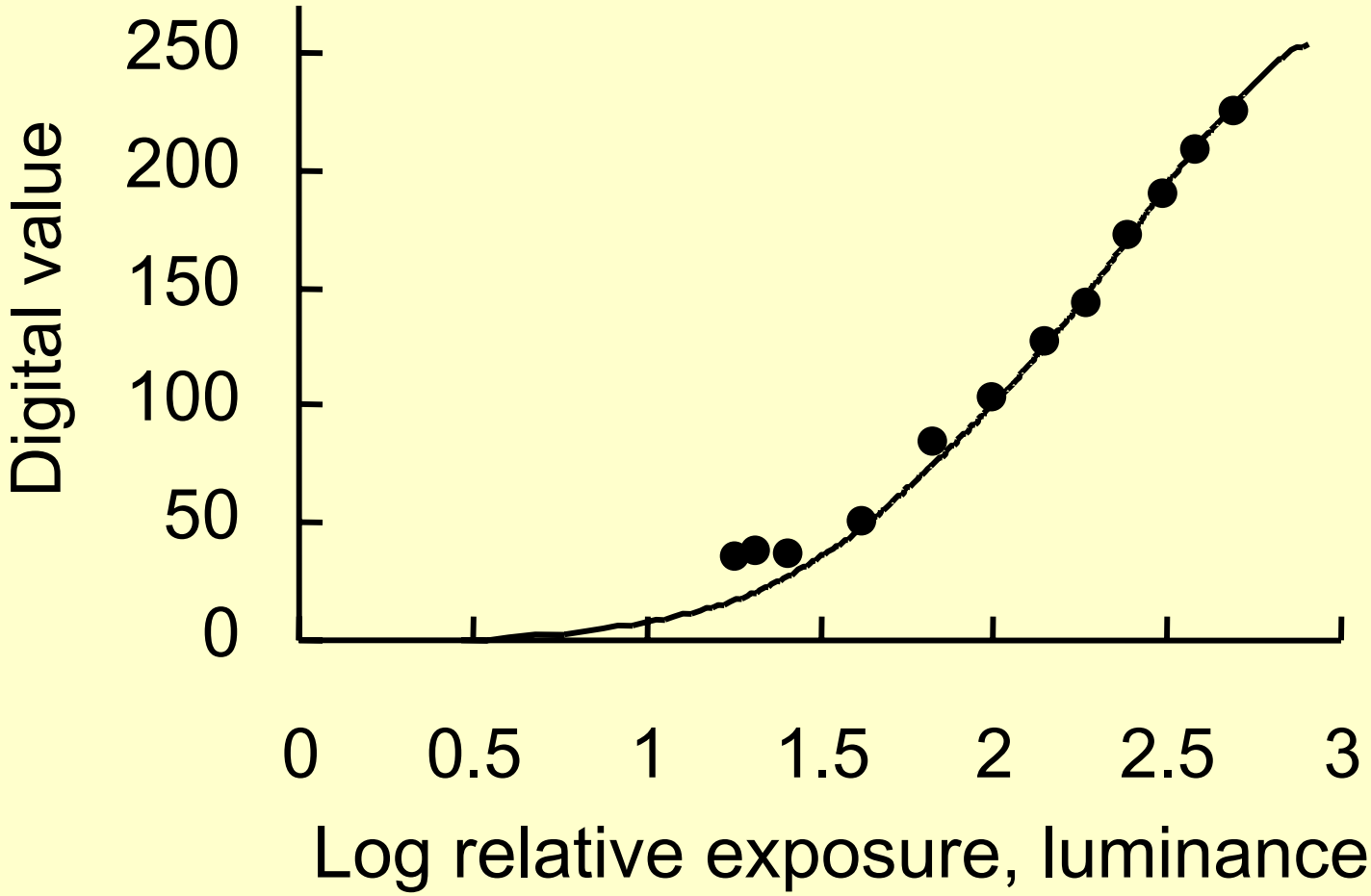
Cumulative frequencies for red, green, blue and total digital values



Comparison to gray scale



Comparison to gray scale



Summary

A new method for determining the tone conversion characteristics of a digital still camera from two pictorial images without a gray scale has been developed.

After comparison to that with the conventional method using a gray scale, same results with much points have been obtained.

The new method will be expected to apply color management.