Bab 8 Pemrosesan Citra

Dr.Ir. Yeffry Handoko Putra, M.T

Image Formation

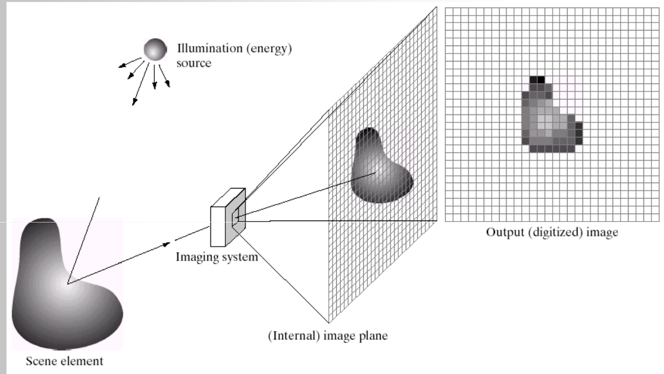


FIGURE 2.15 An example of the digital image acquisition process. (a) Energy ("illumination") source. (b) An element of a scene. (c) Imaging system. (d) Projection of the scene onto the image plane. (e) Digitized image.

*f(x,y) = reflectance(x,y) * illumination(x,y)*
Reflectance in [0,1], illumination in [0,inf]

Sampling and Quantization

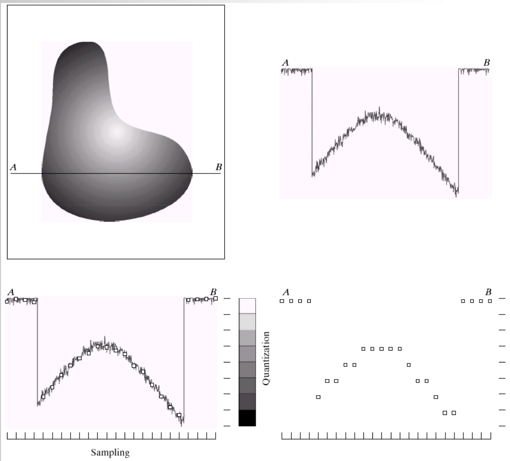


FIGURE 2.16 Generating a digital image. (a) Continuous image. (b) A scan line from *A* to *B* in the continuous image, used to illustrate the concepts of sampling and quantization. (c) Sampling and quantization. (d) Digital scan line.

Sampling and Quantization

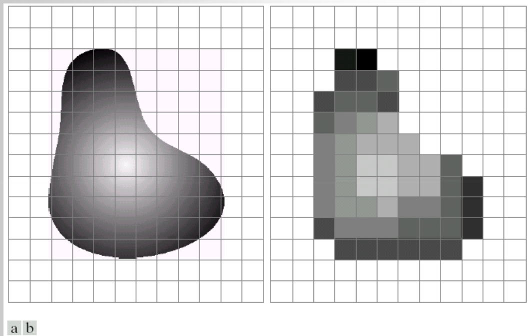


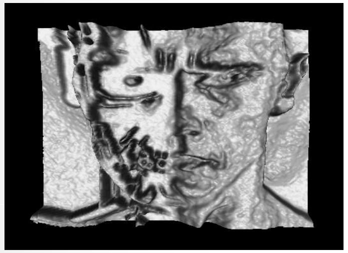
FIGURE 2.17 (a) Continuos image projected onto a sensor array. (b) Result of image sampling and quantization.

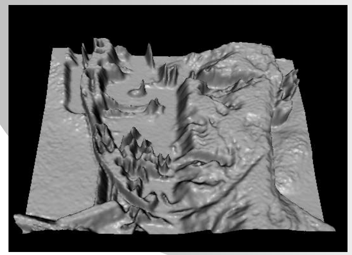
Apa itu Citra (image)?

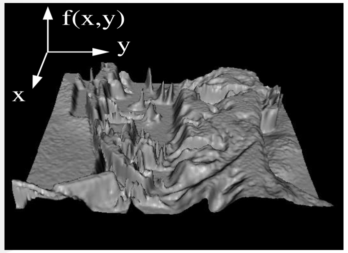
- **Citra merupakan sebuah fungsi**, *f*, from $\mathbb{R}^2$ to $\mathbb{R}$:
  - $f(x, y)$ gives the **intensity** at position (x, y)
  - Secara realistik, image 2D hanya dapat didefinisikan berupa sebuah kotak dengan rentang terbatas :
    - $f: [a,b] \times [c,d] \rightarrow [0,1]$
- Warna citra adalah tiga fungsi yang dapat ditulis sebagai vektor berikut

$$f(x,y) = \begin{bmatrix} r(x,y) \\ g(x,y) \\ b(x,y) \end{bmatrix}$$

Citra sebagai fungsi







Apa itu Citra Digital ?

- Ciri citra digital adalah mengalami proses digital (discrete) :
  - **Sample** : dari ruang 2D menjadi grid kotak
  - **Quantize** : dibulatkan nilainya
- Citra 2D dapat dinyatakan dalam matriks integer

j →, i ↓

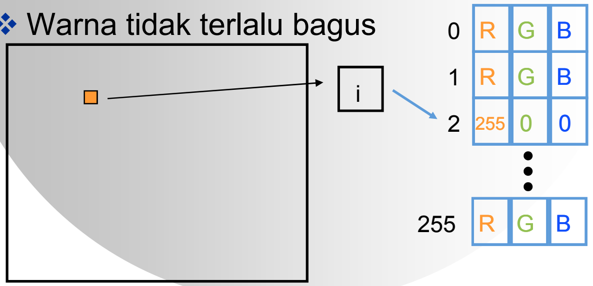
62	79	23	119	120	105	4	0
10	10	9	62	12	78	34	0
10	58	197	46	46	0	0	48
176	135	5	188	191	68	0	49
2	1	1	29	26	37	0	77
0	89	144	147	187	102	62	208
255	252	0	166	123	62	0	31
166	63	127	17	1	0	99	30

Penyimpanan Citra

- Citra disimpan di memory sebagai array piksel 2D
- Nilai setiap piksel menentukan warna
- Kedalaman (Depth) dari citra adalah informasi per piksel
  - 1 bit: black and white display
  - 8 bit: 256 colors pada suatu waktu ditentukan oleh colormap
  - 16 bit: 5, 6, 5 bits (R,G,B), 2^{16} = 65,536 colors
  - 24 bit: 8, 8, 8 bits (R,G,B), 2^{24} = 16,777,216 colors

Colormap

- Colormaps biasanya untuk 8 bit framebuffer depth
- Untuk layar 1024 * 768 = 786432 = 0.75 MB
- Setiap nilai piksel merupakan nilai indeks dari colormap
- Colormap adalah array niali RGB values, yang masing-masingnya 8 bits
- Hanya 2^8 = 256 untuk satu waktu
- Warna tidak terlalu bagus



Pemrosesan Citra

- Merupakan bentuk pemrosesan sinyal 2D
- Citra sebagai sinyal 2D
  - Point processing: memodifikasi piksel secara independen
  - Filtering: modifikasi berdasarkan piksel tetangga
  - Compositing: menggabungkan beberapa citra
  - Image compression
  - Image enhancement and restoration
  - Computer vision

Pemrosesan titik (Point Processing)

- Transformasi rentang paling sederhana
- Input: a[x,y], Output b[x,y] = f(a[x,y])
- Fungsi f mentrasformasikan piksel secara terpisah
- Berguna untuk pengaturan kontras

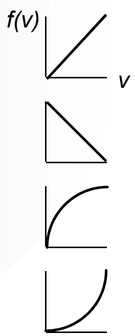
Misal gambar kita adalah grayscale (monokrom) dan v adalah nilai piksel maka transformasinya :

f(v) = v identity; no change

f(v) = 1-v negate an image
(black to white, white to black)

f(v) = v^p, p<1 brighten

f(v) = v^p, p>1 darken



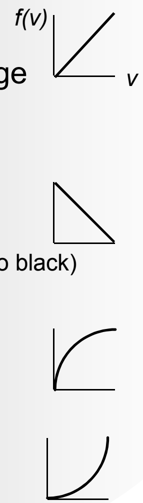
Pemrosesan Titik (Point Processing)

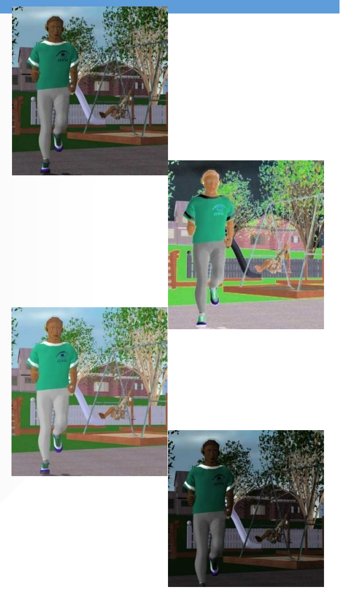
f(v) = v identity; no change

f(v) = 1-v negate an image
(black to white, white to black)

f(v) = v^p, p<1 brighten

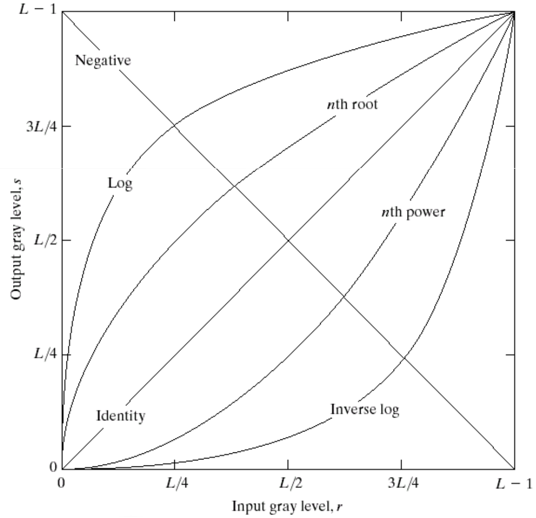
f(v) = v^p, p>1 darken





Fungsi Pemrosesan Titik yang umum

FIGURE 3.3 Some basic gray-level transformation functions used for image enhancement.



Hukum Daya Transformasi (Power-law Transformation)

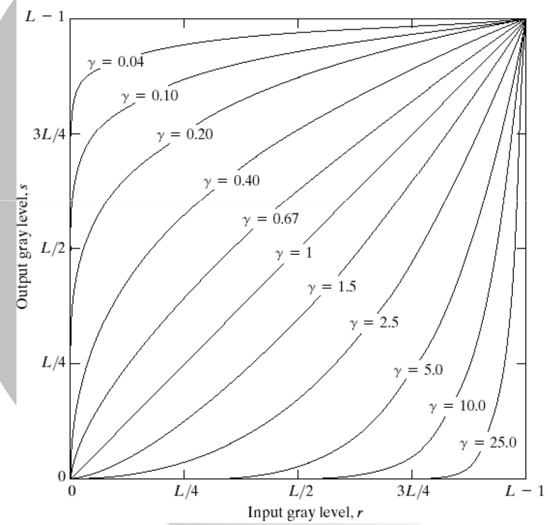
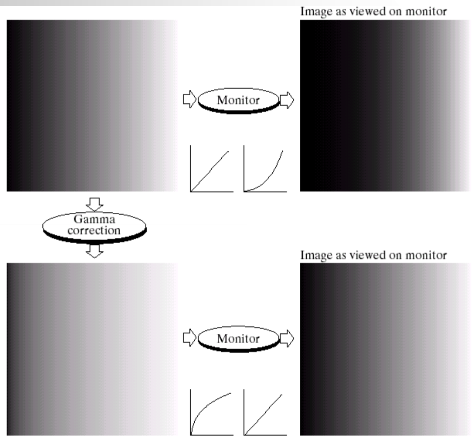


FIGURE 3.6 Plots of the equation $s = cr^{\gamma}$ for various values of γ ($c = 1$ in all cases).

Gamma Correction

a b
c d

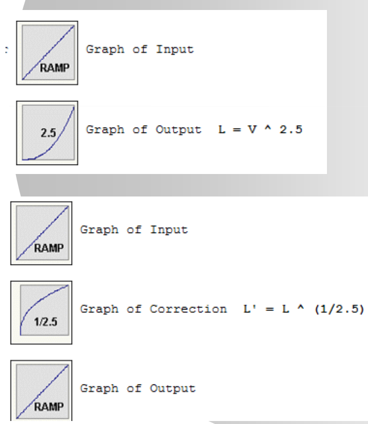
FIGURE 3.7 (a) Linear-wedge gray-scale image. (b) Response of monitor to linear wedge. (c) Gamma-corrected wedge. (d) Output of monitor.



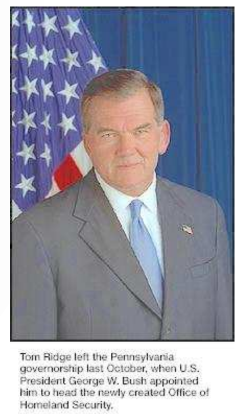
Gamma Measuring Applet:
http://www.cs.berkeley.edu/~efros/java/gamma/gamma.html

Koreksi Gamma untuk mengkompensasi monitor yang berbeda monitors

Monitor memiliki respon intensitas terhadap tegangan sebagai fungsi kelipatan 2,5
Saat mengirim v → intentsitas pikselmenjadi $v^{2,5}$

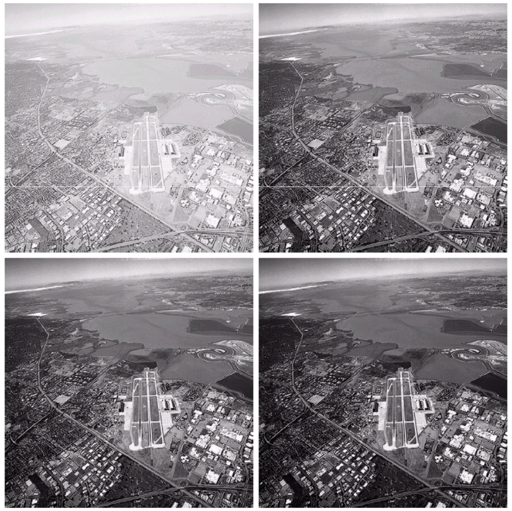


$\Gamma = 1.0$; $f(v) = v$



$\Gamma = 2.5$; $f(v) = v^{1/2.5} = v^{0.4}$

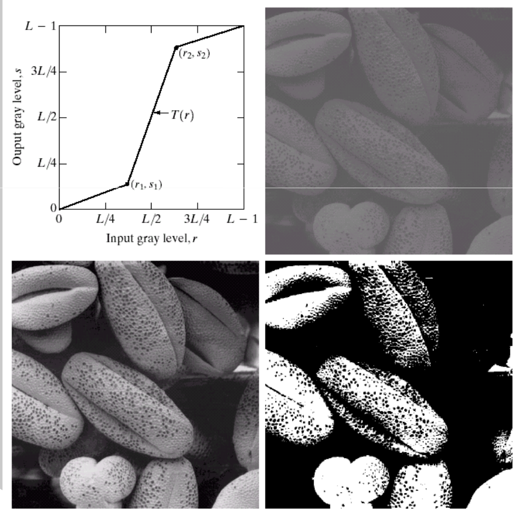
Image Enhancement



a b
c d

FIGURE 3.9 (a) Aerial image. (b)–(d) Results of applying the transformation in Eq. (3.2-3) with $c = 1$ and $\gamma = 3.0, 4.0$, and 5.0, respectively. (Original image for this example courtesy of NASA.)

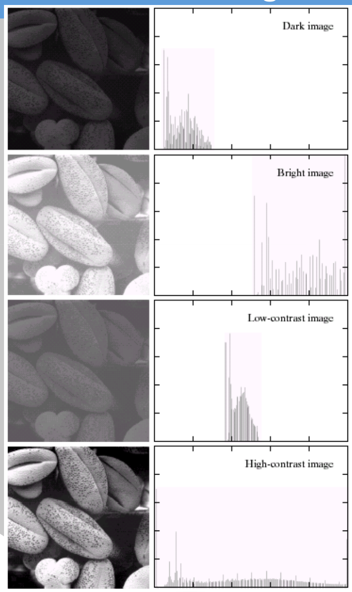
Contrast Streching



a b
c d

FIGURE 3.10 Contrast stretching. (a) Form of transformation function. (b) A low-contrast image. (c) Result of contrast stretching. (d) Result of thresholding. (Original image courtesy of Dr. Roger Heady, Research School of Biological Sciences, Australian National University, Canberra, Australia.)

Image Histograms

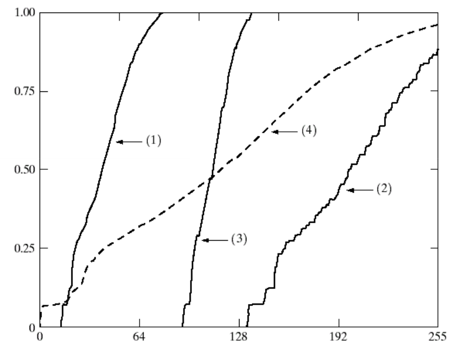


a b

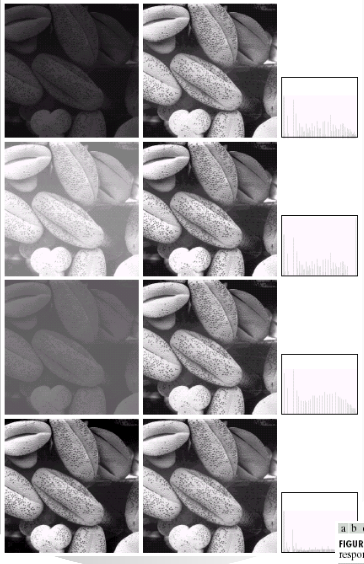
FIGURE 3.15 Four basic image types: dark, light, low contrast, high contrast, and their corresponding histograms. (Original image courtesy of Dr. Roger Heady, Research School of Biological Sciences, Australian National University, Canberra, Australia.)

Cumulative Histograms

FIGURE 3.18 Transformation functions (1) through (4) were obtained from the histograms of the images in Fig.3.17(a), using Eq. (3.3-8).



Histogram Equalization



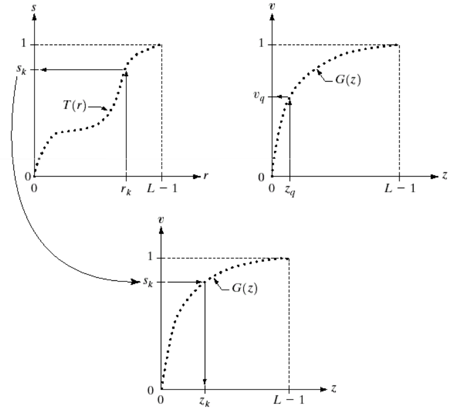
a b c

FIGURE 3.17 (a) Images from Fig. 3.15. (b) Results of histogram equalization. (c) Corresponding histograms.

Histogram Matching

a b
c

FIGURE 3.19 (a) Graphical interpretation of mapping from r_k to s_k via $T(r)$. (b) Mapping of z_q to its corresponding value v_q via $G(z)$. (c) Inverse mapping from s_k to its corresponding value of z_k.



Match-histogram code

```
Match-histogram (im1,im2)
  im1-cdf = Make-cdf(im1)
  im2-cdf = Make-cdf(im2)
  inv-im2-cdf = Make-inverse-lookup-table(im2-cdf)
  Loop for each pixel do
       im1[pixel] =
         Lookup(inv-im2-cdf,
                Lookup(im1-cdf,im1[pixel]))
```

Outline

- Point Processing
- Filters
- Dithering
- Image Compositing
- Image Compression

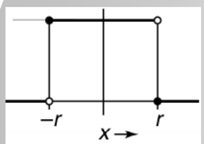
Signal dan Filter

- Perekaman audio adalah sinyal 1D : amplituda(t)
- Citra adalah Sinyal 2D signal: color(x,y)
- Sinyal bisa kontinyu atau diskrit
- Citra raster adalah diskrit
  - In space: sampled in x, y
  - In color: quantized in value
- Filtering: pemetaan sinyal ke sinyal

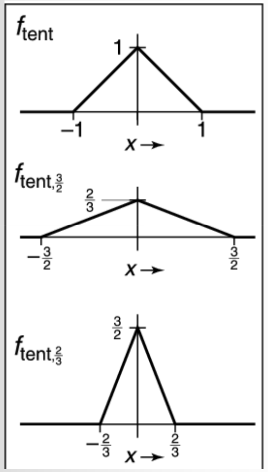
Konvolusi

- Digunakan untuk proses filter, sampling dan rekonstruksi
- Konvolusi 1D

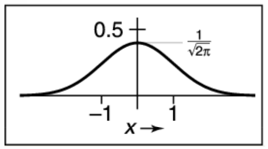
Convolution filters



box



tent



gaussian

Filter dengan konvolusi

- Konvolusi dalam 1D
  - a(t) is input signal
  - b(s) is output signal
  - h(u) is filter

$$b(s) = \sum_{t=-\infty}^{+\infty} a(t)h(s-t)$$

- Konvolusi dalam 2D

$$b(x,y) = \sum_{u=-\infty}^{+\infty} \sum_{v=-\infty}^{+\infty} a(u,v)h(x-u,y-v)$$