

Bab 8 Pemrosesan Citra

Dr.Ir. Yeffry Handoko Putra, M.T

1



Image Formation

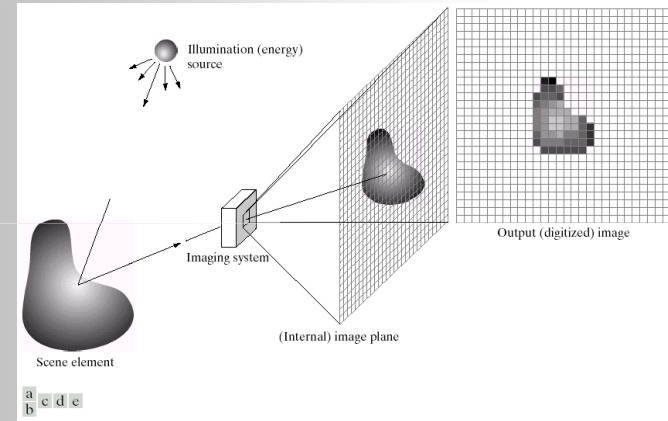


FIGURE 2.15 An example of the digital image acquisition process. (a) Energy ("illumination") source. (b) An element of a scene. (c) Imaging system. (d) Projection of the scene onto the image plane. (e) Digitized image.

$$f(x,y) = \text{reflectance}(x,y) * \text{illumination}(x,y)$$

Reflectance in $[0, 1]$, illumination in $[0, \text{inf}]$

2



Sampling and Quantization

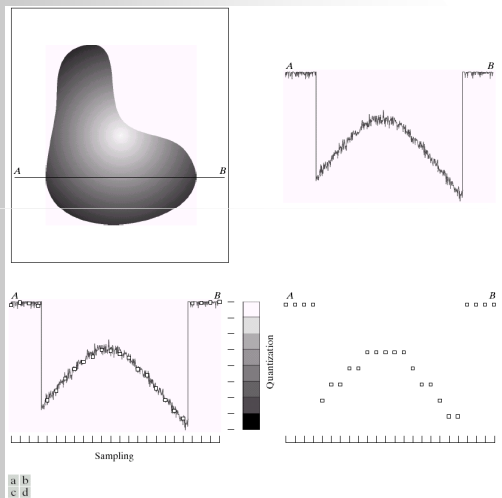


FIGURE 2.16 Generating a digital image. (a) Continuous image. (b) A scan line from A to B in the continuous image, used to illustrate the concepts of sampling and quantization. (c) Sampling and quantization. (d) Digital scan line.

3



Sampling and Quantization

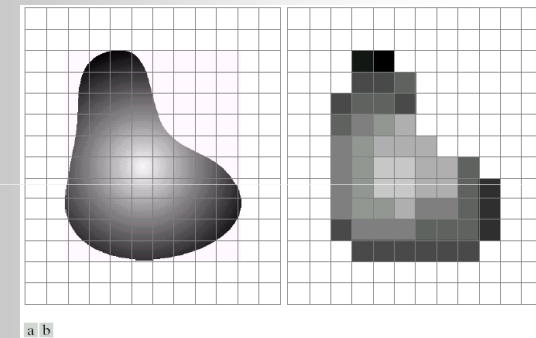


FIGURE 2.17 (a) Continuous image projected onto a sensor array. (b) Result of image sampling and quantization.

4



Apa itu Citra (image)?



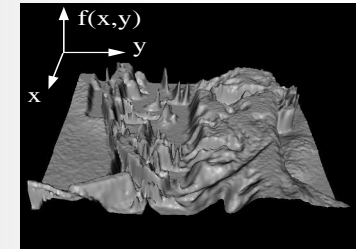
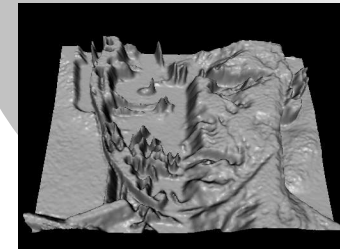
- ❖ **Citra merupakan sebuah fungsi, f , from \mathbb{R}^2 to \mathbb{R} :**
 - $f(x, y)$ gives the **intensity** at position (x, y)
 - Secara realistik, image 2D hanya dapat didefinisikan berupa sebuah kotak dengan rentang terbatas :
 - $f: [a,b] \times [c,d] \rightarrow [0,1]$
- ❖ Warna citra adalah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

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

5



Citra sebagai fungsi



6



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

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

7



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

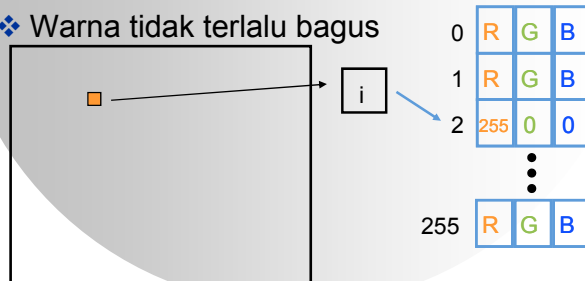
8



Colormap



- ❖ Colormaps biasanya untuk 8 bit framebuffer depth
- ❖ Untuk layar $1024 * 768 = 786432 = 0.75 \text{ MB}$
- ❖ Setiap nilai piksel merupakan nilai indeks dari colormap
- ❖ Colormap adalah array nilai 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 mentransformasikan piksel secara terpisah
- ❖ Berguna untuk pengaturan kontras

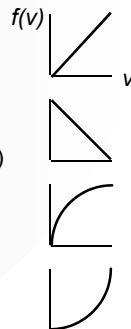
Misal gambar kita adalah grayscale (monokrom) dan v adalah nilai piksel maka transformasinya :

$f(v) = v$ 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)

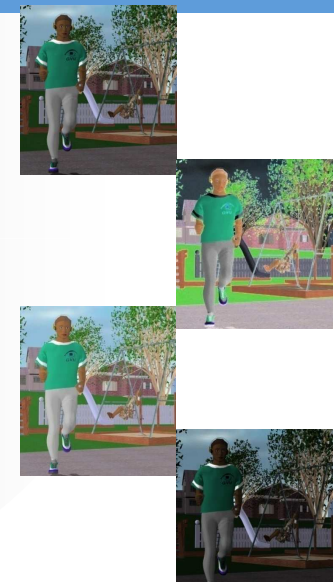
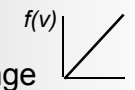


$f(v) = v$ identity; no change

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

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

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

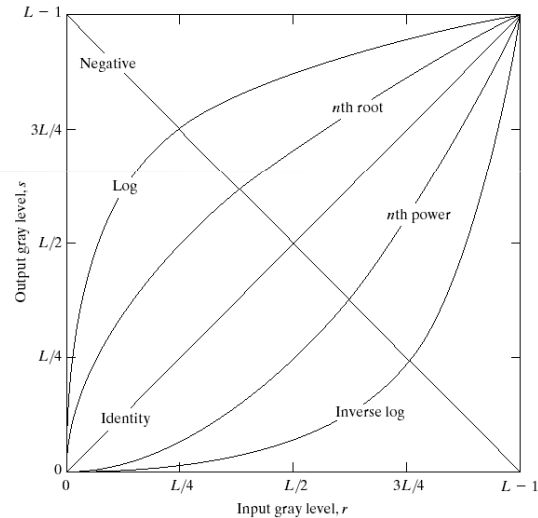




Fungsi Pemrosesan Titik yang umum



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



13



Hukum Daya Transformasi (Power-law Transformation)

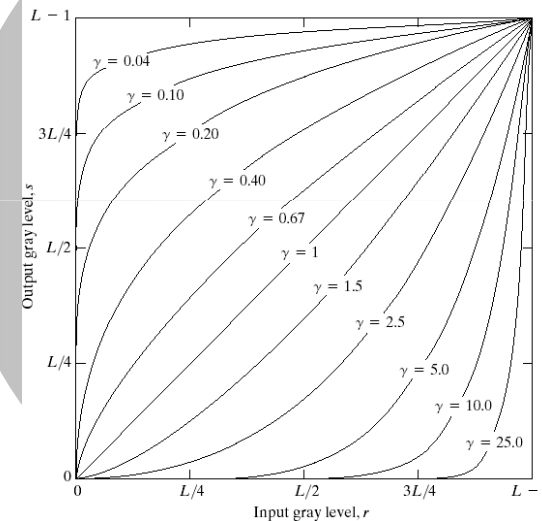


FIGURE 3.6 Plots of the equation $s = cr^\gamma$ for various values of γ ($c = 1$ in all cases).



Gamma Correction

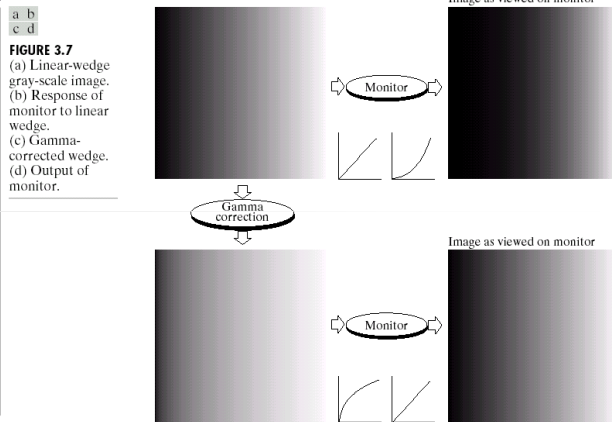


FIGURE 3.7 (a) Linear-wedge gray-scale image. (b) Response of monitor to linear wedge. (c) Gamma-corrected wedge. (d) Output of monitor.

Gamma Measuring Applet:

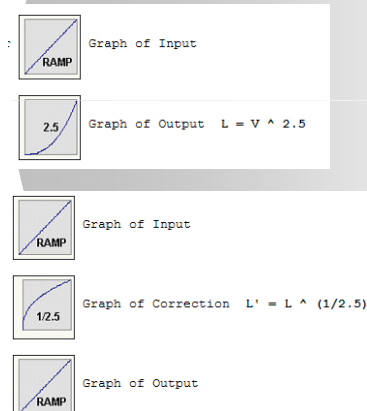
<http://www.cs.berkeley.edu/~efros/java/gamma/gamma.html>



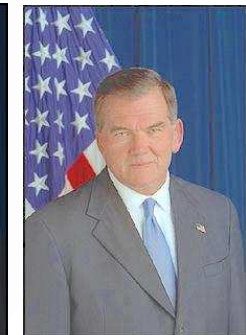
Koreksi Gamma untuk mengkompensasi monitor yang berbeda monitors



Monitor memiliki respon intensitas terhadap tegangan sebagai fungsi kelipatan 2,5
Saat mengirim $v \rightarrow$ intensitas piksel menjadi $v^{2.5}$



Tom Ridge left the Pennsylvania governorship last October, when U.S. President George W. Bush appointed him to head the newly created Office of Homeland Security.



Tom Ridge left the Pennsylvania governorship last October, when U.S. President George W. Bush appointed him to head the newly created Office of Homeland Security.

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

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



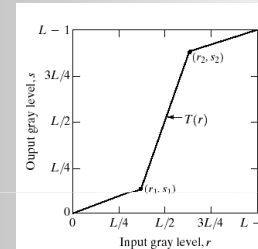
Image Enhancement

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
courtesy of
NASA.)



Contrast Stretching



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.)

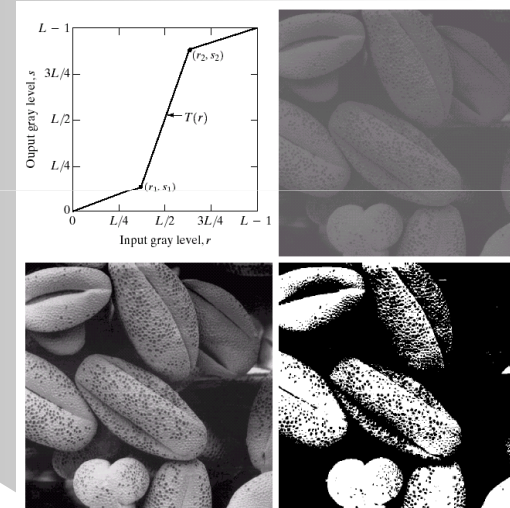
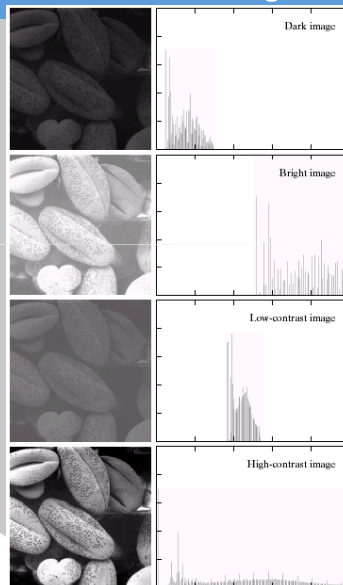


Image Histograms



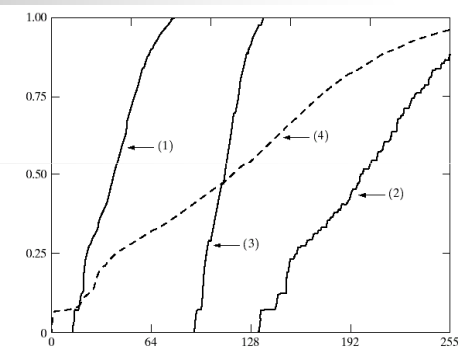
a b

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

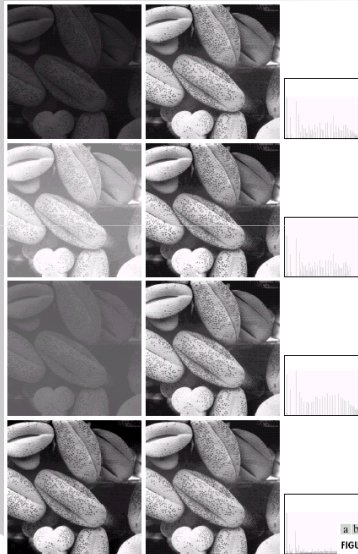
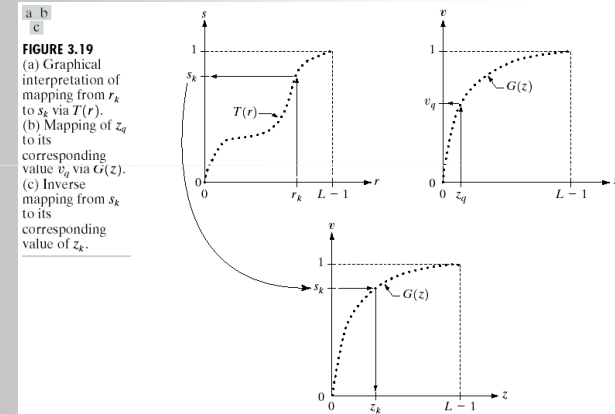


FIGURE 3.17 (a) Images from Fig. 3.15. (b) Results of histogram equalization. (c) Corresponding histograms.



Histogram Matching



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 : amplitudo(t)
- ❖ Citra adalah Sinyal 2D signal: color(x,y)
- ❖ Sinyal bisa kontinu atau diskrit
- ❖ Citra raster adalah diskrit
 - In space: sampled in x, y
 - In color: quantized in value
- ❖ Filtering: pemetaan sinyal ke sinyal

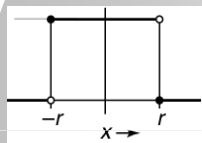


Konvolusi

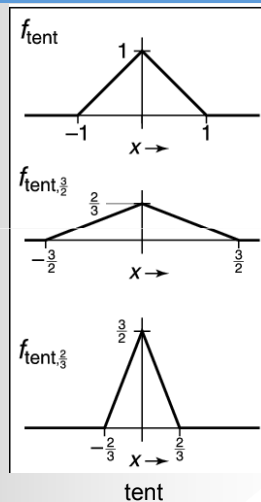
- ❖ Digunakan untuk proses filter, sampling dan rekonstruksi
- ❖ Konvolusi 1D



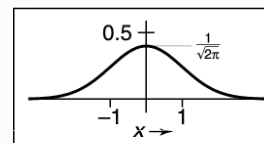
Convolution filters



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

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