21.08.2020

Digital Image Processing (CSE/ECE 478)

Lecture-4: Recap/Discussion

Ravi Kiran

Center for Visual Information Technology (CVIT), IIIT Hyderabad

Announcements

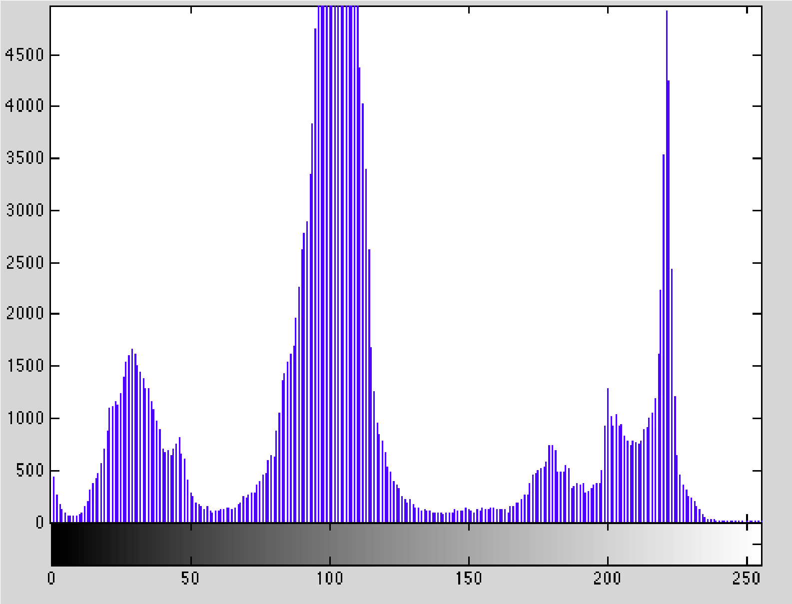
- Mini-quiz-1
  - For those who could not submit : Best 5 of 7 remaining mini-quizzes
  - Others: Default (Best 5 of 8)
- Next quiz (Friday) will be Moodle-based
- Mock quiz will be posted for practice.

Histogram: An image representation + visualization

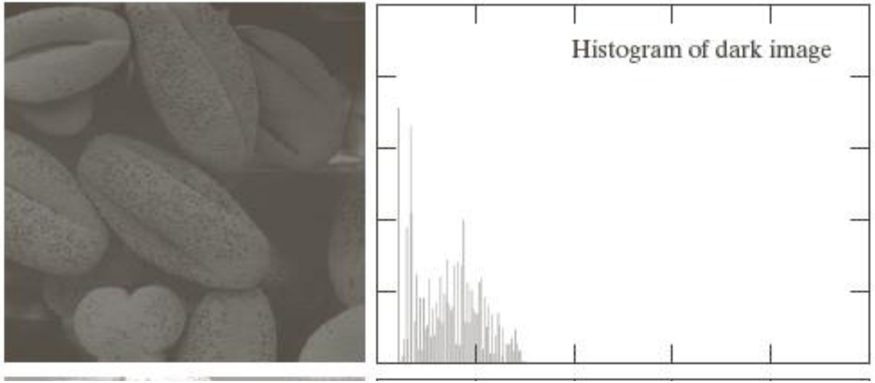
$$h_r(i) = n_i$$

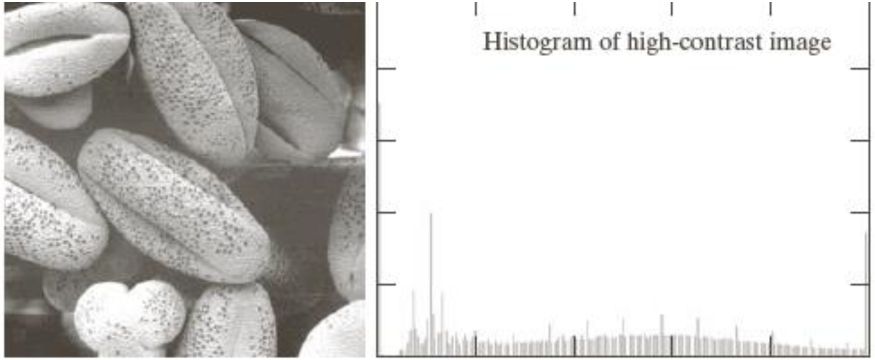
i → intensity value, range [0, L-1]

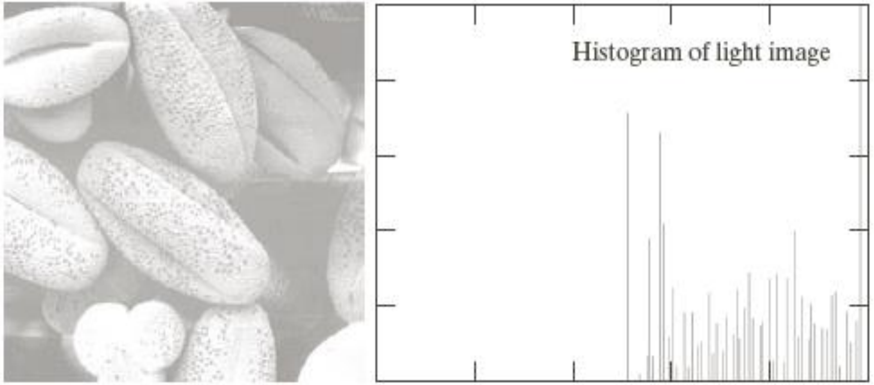
n_i → number of pixels with intensity i

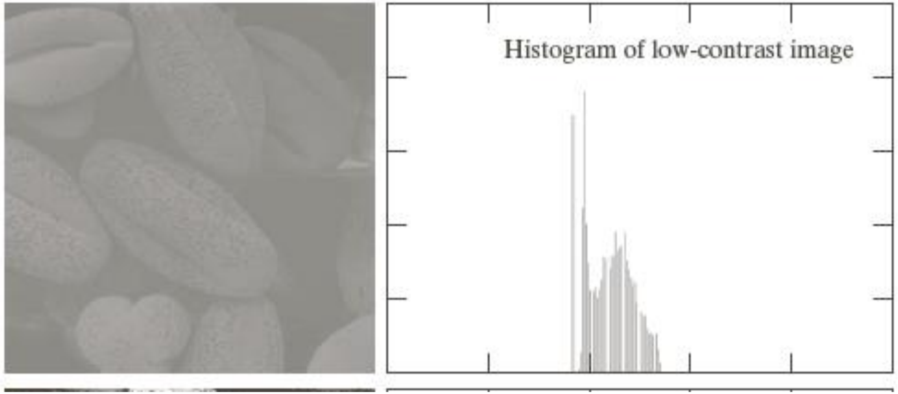


Histograms and Contrast

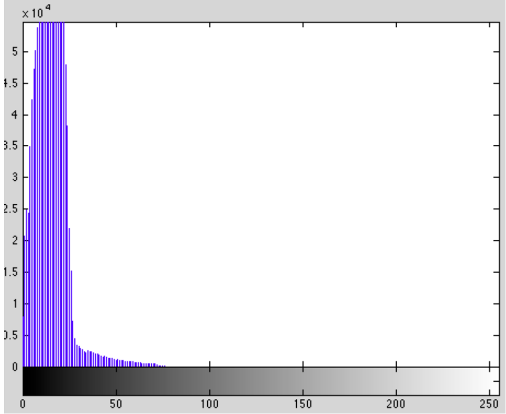


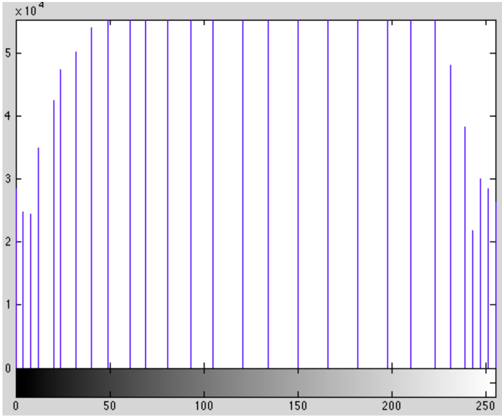






Histogram Equalization





Histogram Equalization - Example

64 x 64 image

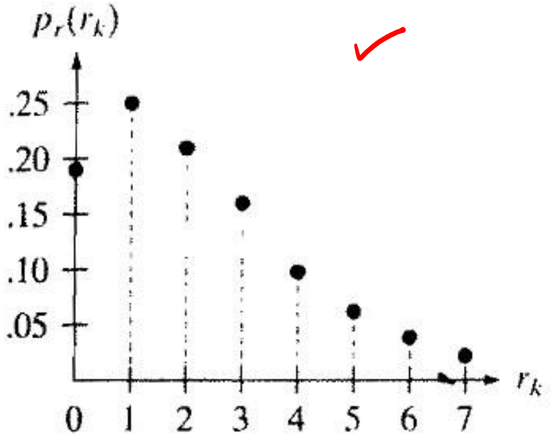
3-bits / pixel

N = 64

M = 64

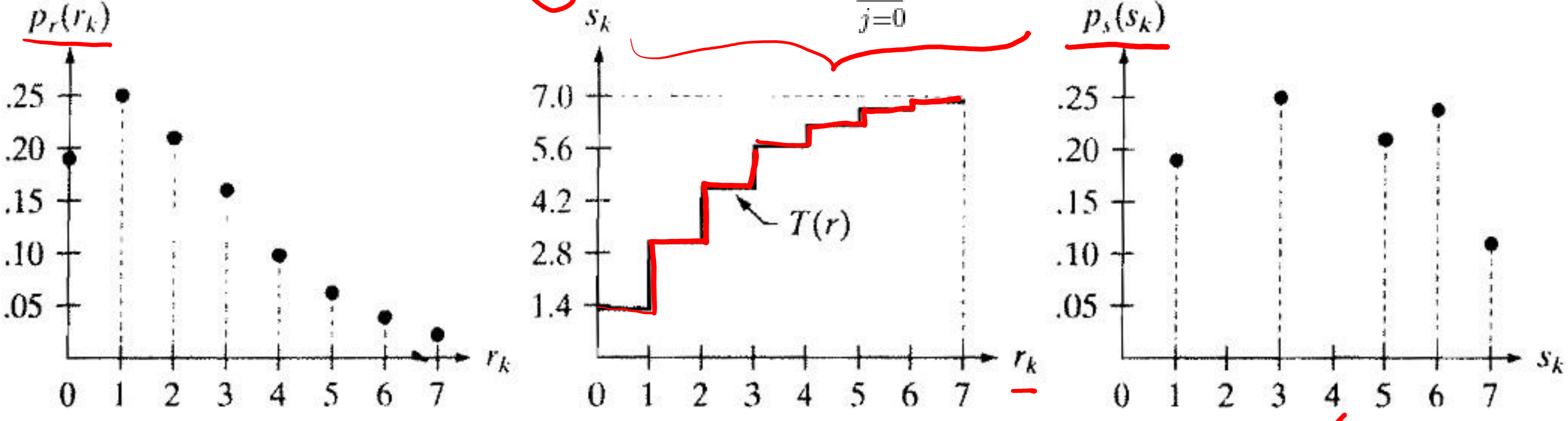
r_k	n_k	$p_r(r_k) = n_k/MN$
$r_0 = 0$	790	0.19
$r_1 = 1$	1023	0.25
$r_2 = 2$	850	0.21
$r_3 = 3$	656	0.16
$r_4 = 4$	329	0.08
$r_5 = 5$	245	0.06
$r_6 = 6$	122	0.03
$r_7 = 7$	81	0.02

MN Σ



Histogram Equalization - Example

$$s_k = \text{round}[(L-1)\sum_{j=0}^{k} p_r(r_k)]$$



a b c

FIGURE 3.19 Illustration of histogram equalization of a 3-bit (8 intensity levels) image. (a) Original histogram. (b) Transformation function. (c) Equalized histogram.

r_k

s_k

Histogram Equalization

$$s_k = T(r_k) = \texttt{round}\left((L-1)\sum_{j=0}^{j=k} p_r(r_j)\right)$$

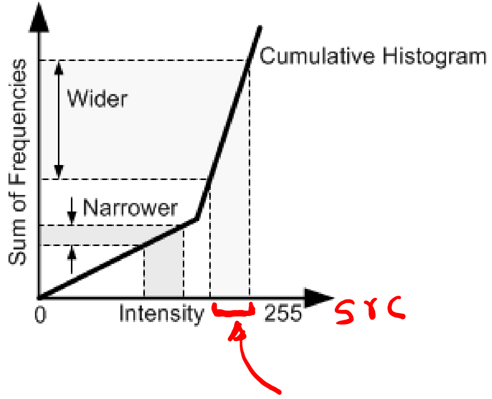
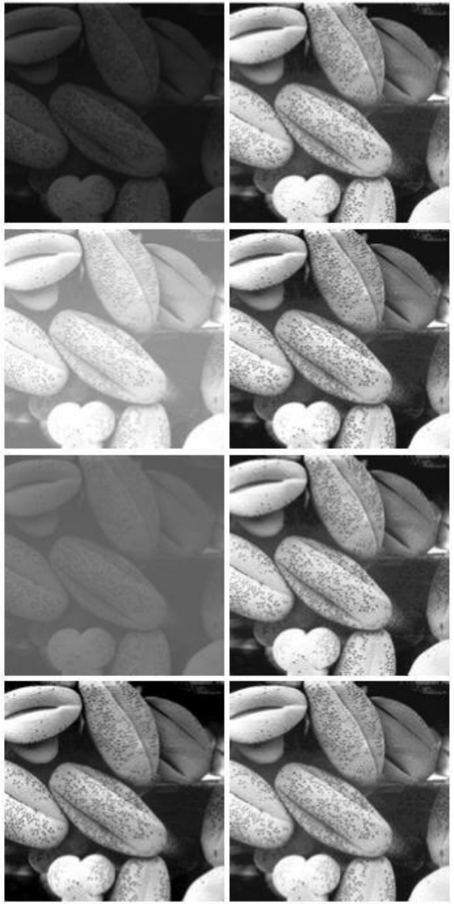


Image Courtesy: Gonzalez and Woods

Histogram Equalization



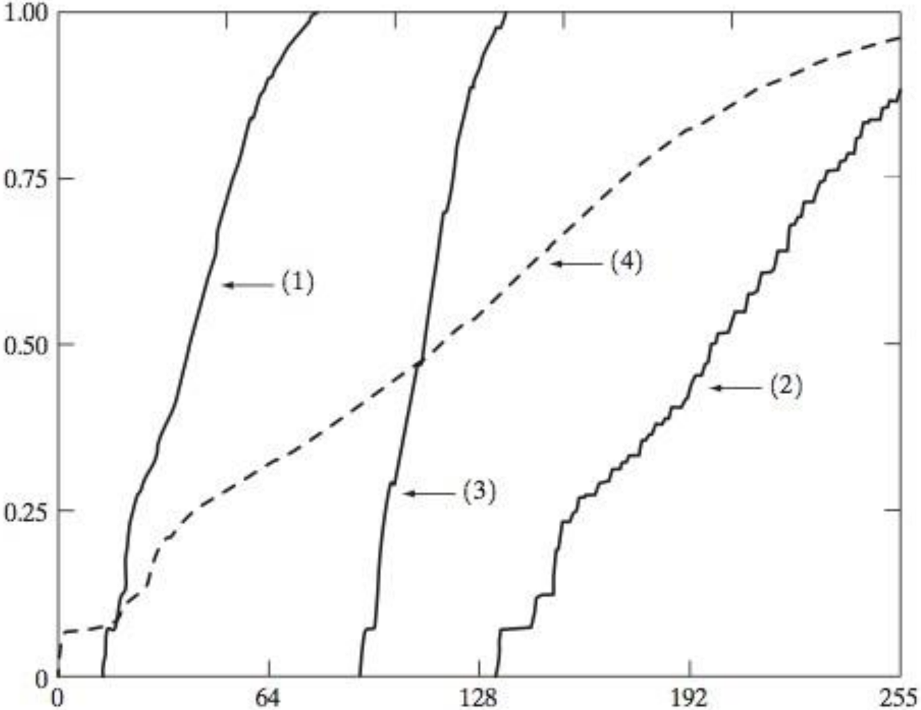
1

2

3

4

$$s_k = T(r_k) = \mathtt{round}\left((L-1)\sum_{j=0}^{j=k} p_r(r_j)\right)$$



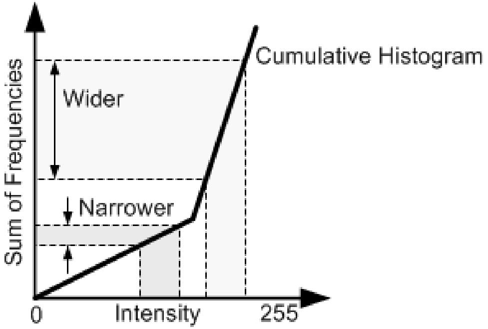


Image Courtesy: Gonzalez and Woods

Histogram Equalization v/s Contrast Enhancement

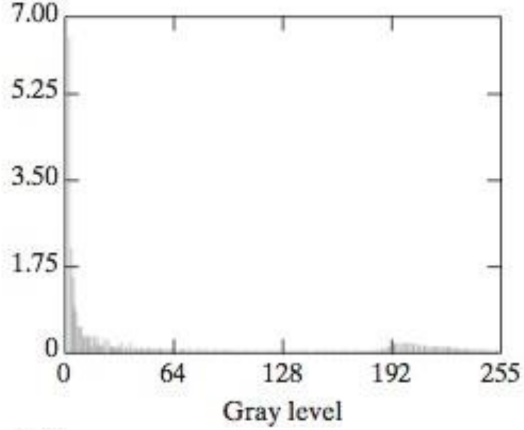
Contrast Enhancement

Histogram equalization

Histogram Equalization

$\hat{I}$

I



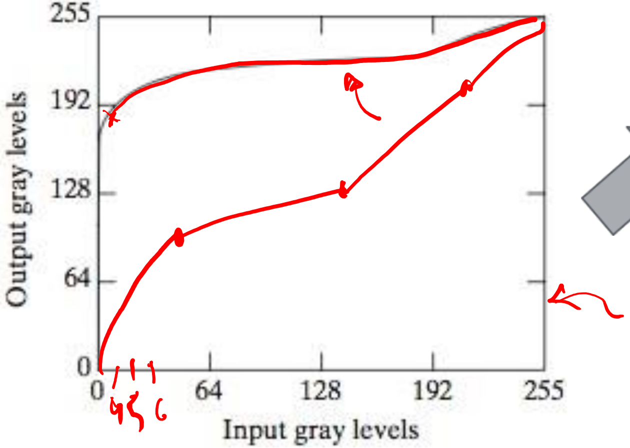
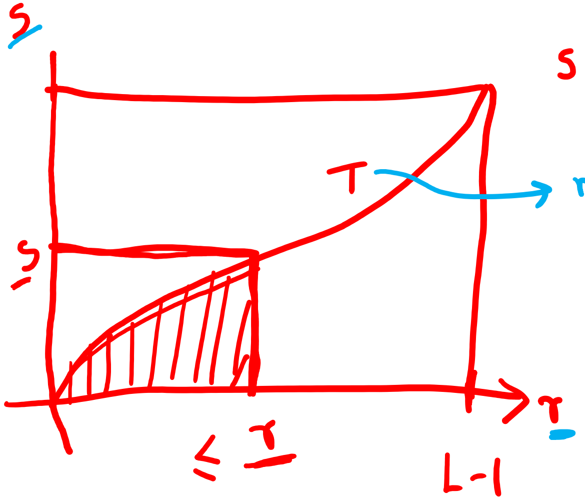


Image Courtesy: Gonzalez and Woods

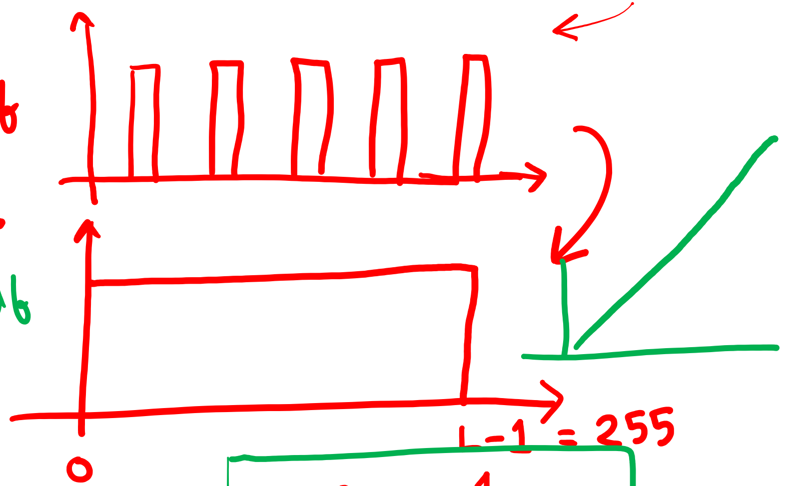
Histogram Equalization



$s = T(r)$

L = # of bits levels

monotonic



$$\boxed{p_S(s) = p_R(r)\frac{dr}{ds}}$$

$$p_S(s)\,ds = p_R(r)\,dr$$

$$\frac{1}{L-1}\,ds = p_R(r)\,dr$$

$$\Rightarrow ds = (L-1)\,p_R(r)\,dr$$

$$\boxed{p_S(s) = \frac{1}{(L-1)}}$$

$$\int_0^{L-1} p_S(s) = 1$$

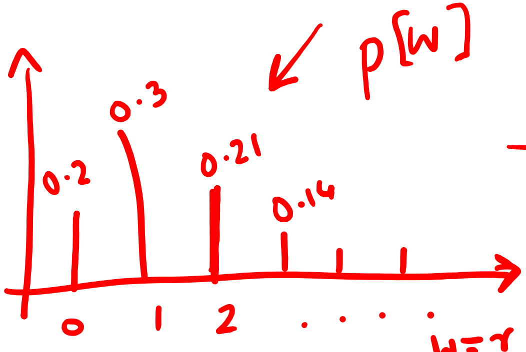
$$s = T(r) = (L-1)\int_0^r p_R(w)\,dw$$

$$\Rightarrow s = (L-1)\int_0^r p_R(w)\,dw$$

Leibniz formula

Histogram Equalization

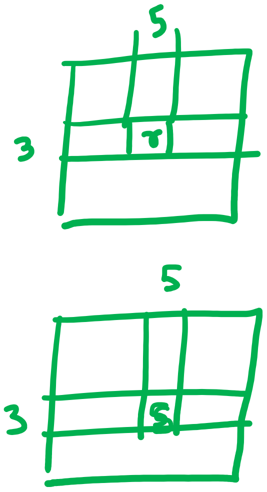
$$p_s(s) = \frac{1}{L-1}$$



$$s = T(\underline{r}) = (L-1)\int_{w=0}^{w=r} P_s(w)\,dw$$

digital equivalent

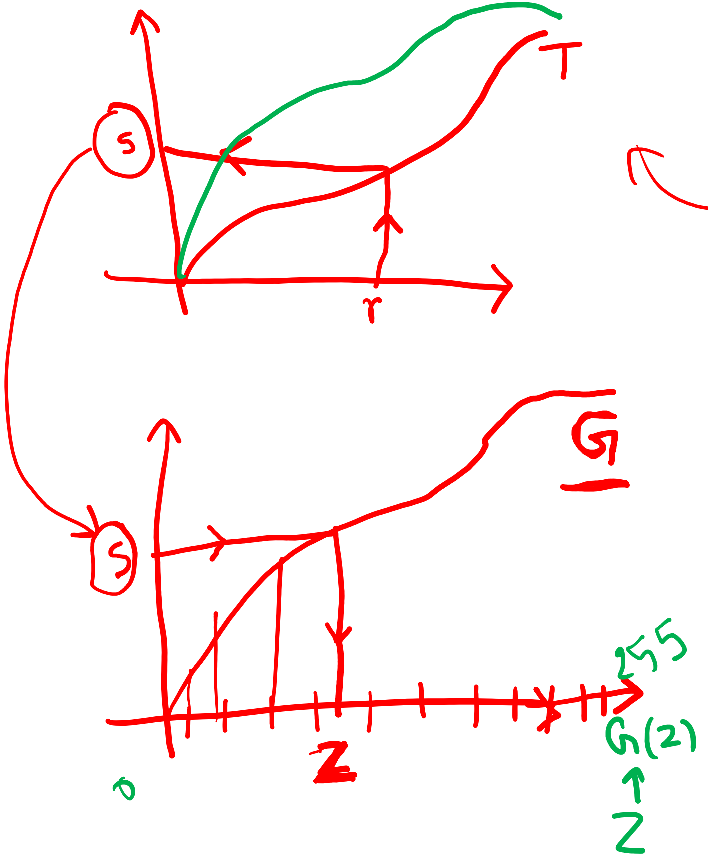
$$\boxed{\underline{s} = \text{round}\left((L-1)\sum_{w=0}^{r} p[w]\right)}$$



Histogram specification

$$s_k = T(r_k) = \texttt{round}\left((L-1)\sum_{j=0}^{j=k} p_r(r_j)\right)$$

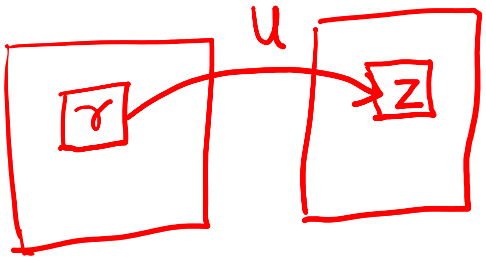
$s = T(r)$ $\quad p_s(s)$



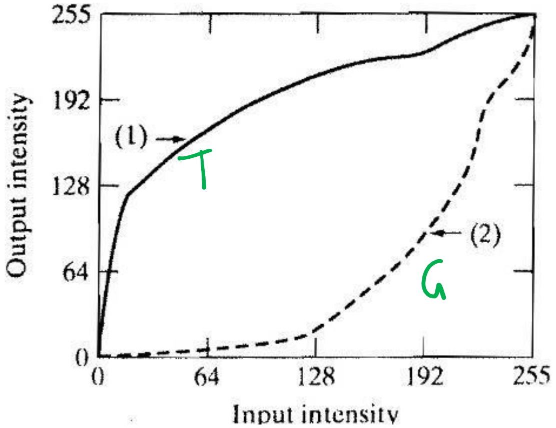
$s = G(z)$

$\Rightarrow z = G^{-1}(s) = G^{-1}(T(r))$

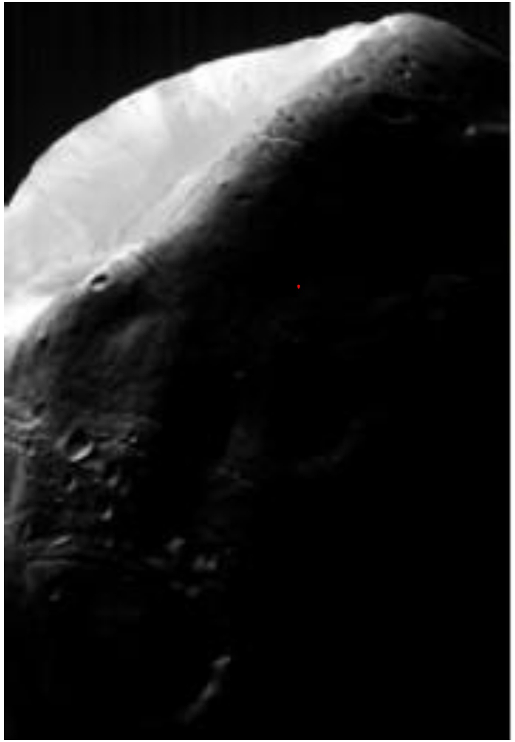
$z = U(r)$



Histogram Specification / Matching [GW Section 3.3.2]



(1)



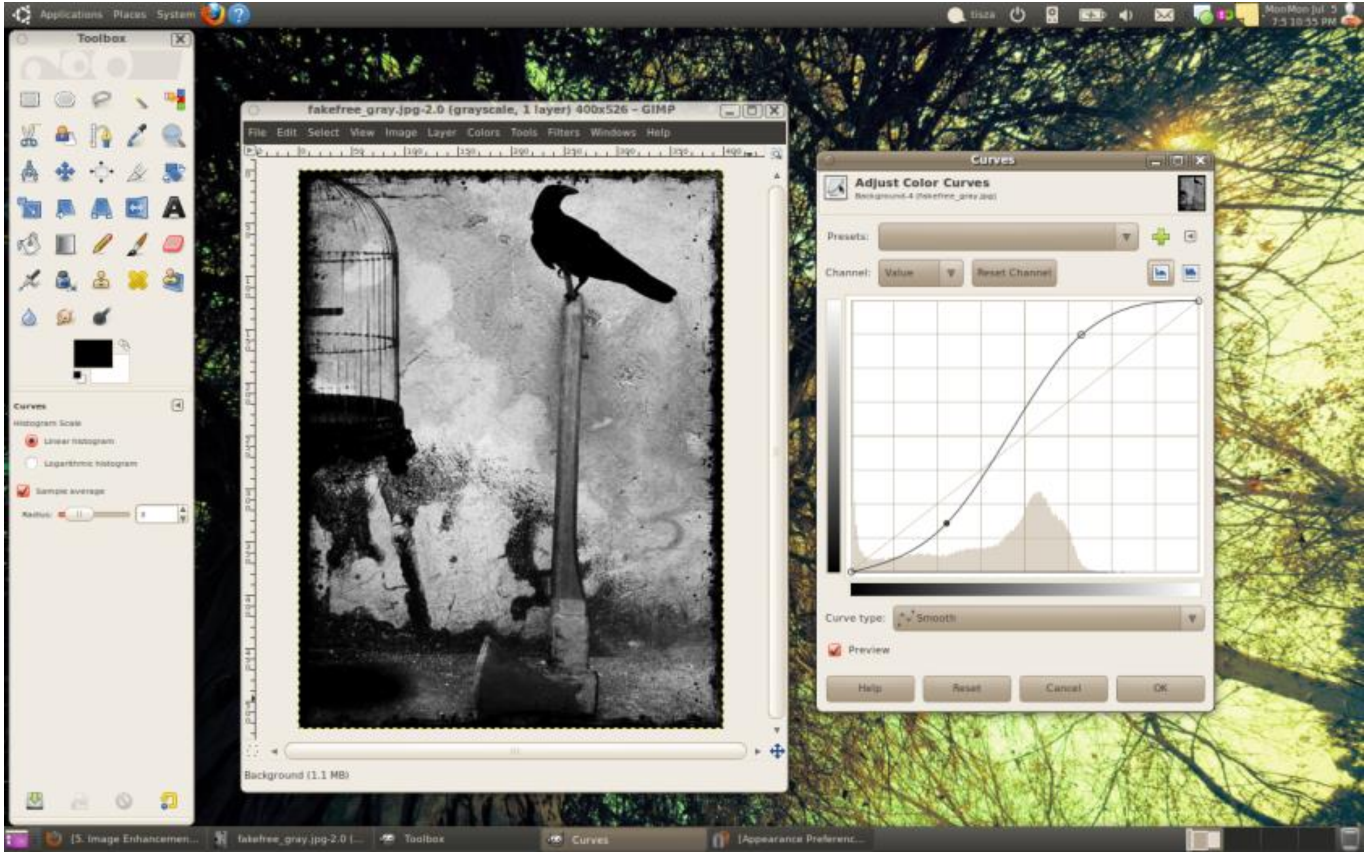
← cumulative

(2)

Image Courtesy: Gonzalez and Woods

Histogram specification (custom curve)

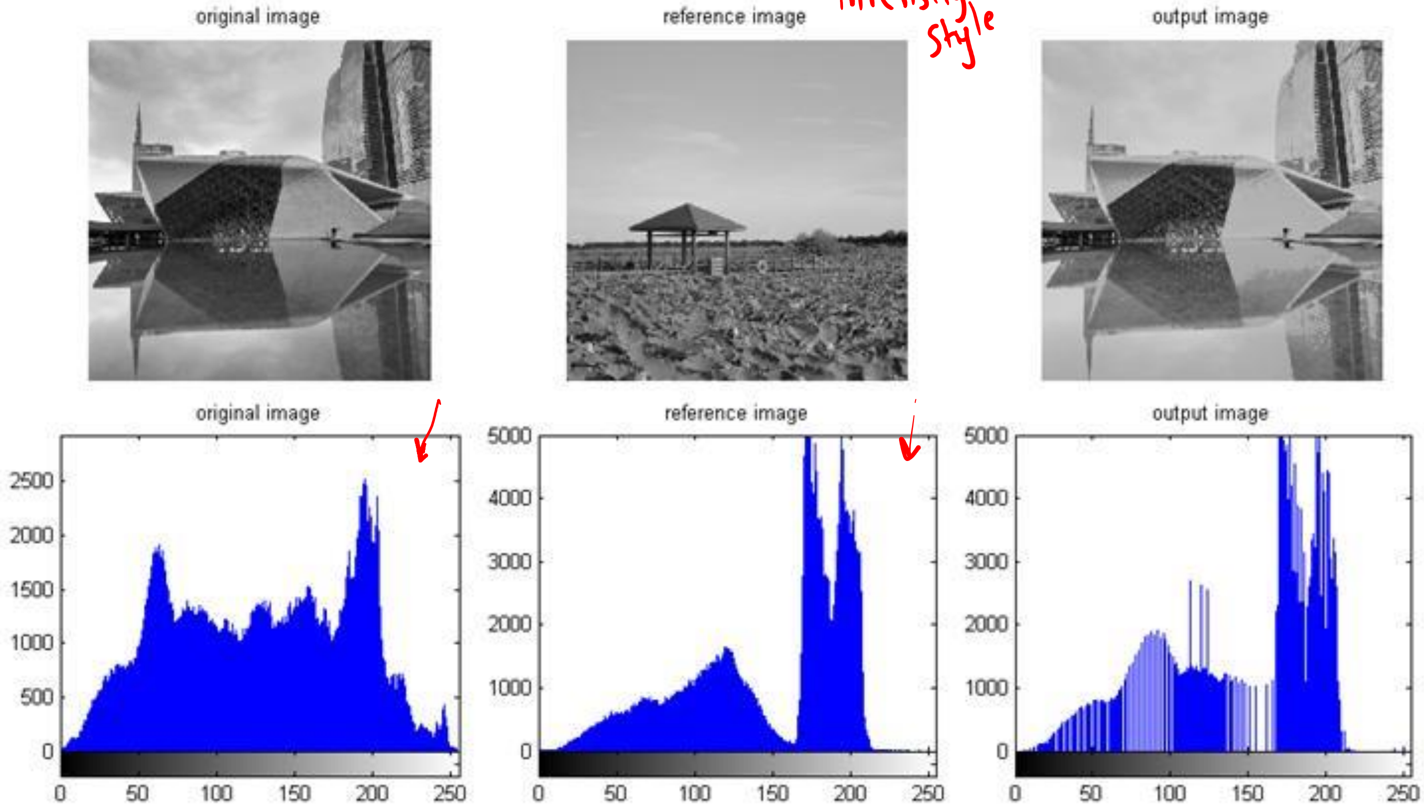
GIMP



https://theiszm.wordpress.com/2010/07/06/5-image-enhancement-by-histogram-manipulation/

Histogram specification (curve from a reference image)

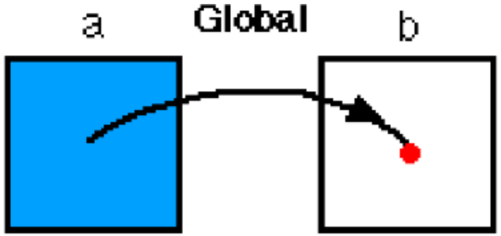
intensity style



https://images1.programmersought.com/152/73/733d674297c6e27a58bdc3d852dca118.png

Histogram Processing

- Global to Point



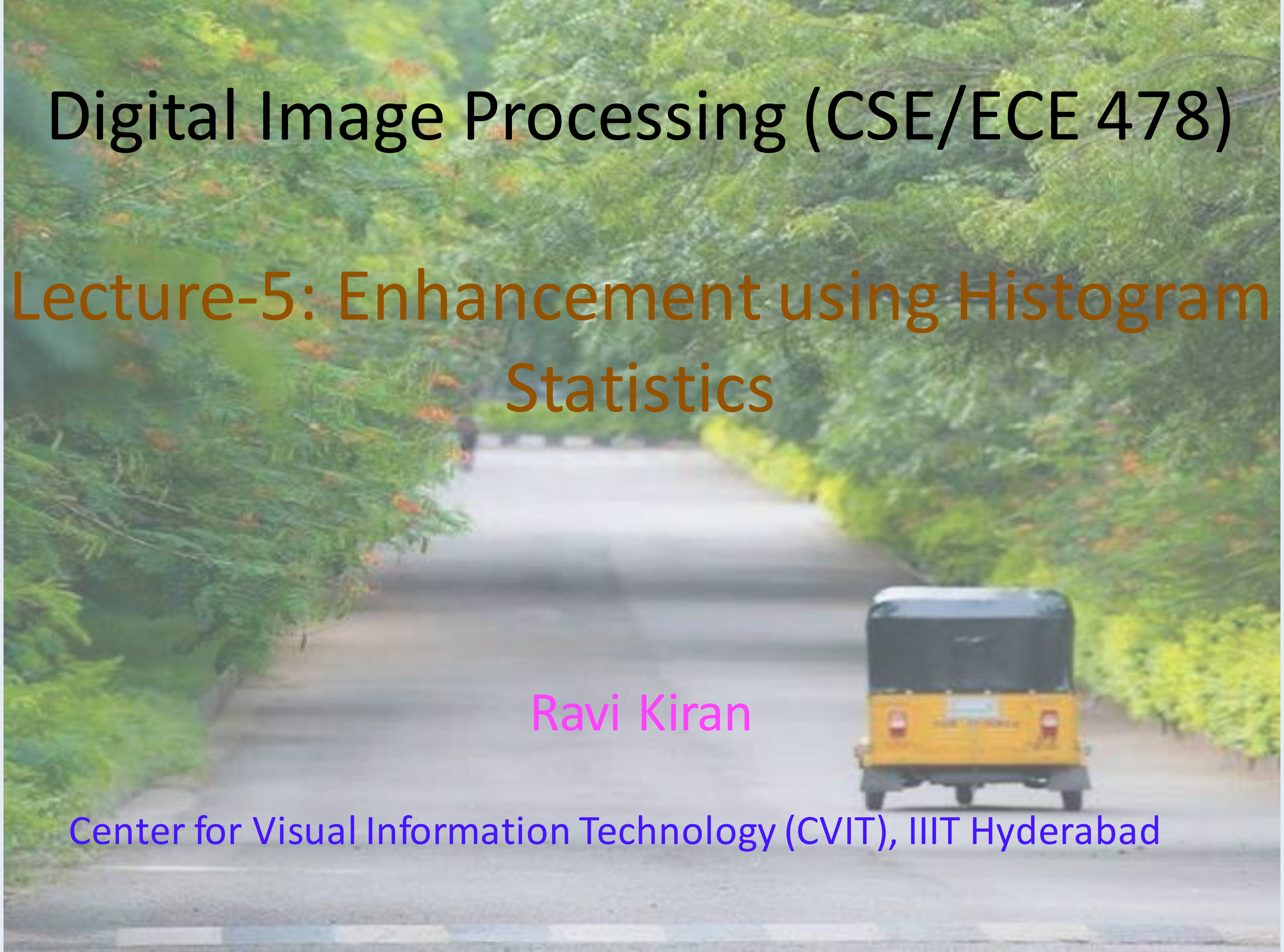
Histogram : Discussion

- A visualization
- A useful statistical representation of image intensities
  - Not dependent on image size (after normalization)
- Drawbacks
  - No spatial information
  - Intensity-centric
  - Raw (unnormalized form): Image-size dependent
- Equalization:
  - An image ‘normalization’ approach
  - Improves global contrast, but can also boost noise

References

- Gonzalez, Woods textbook : Chapter – 3.3.1 to 3.3.3

25.08.2020



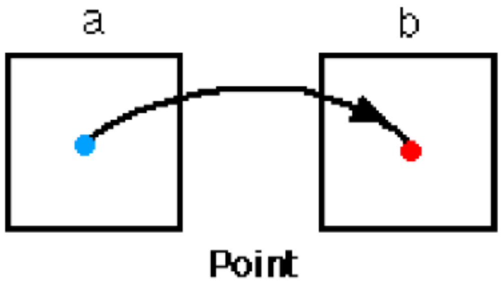
Digital Image Processing (CSE/ECE 478)

Lecture-5: Enhancement using Histogram Statistics

Ravi Kiran

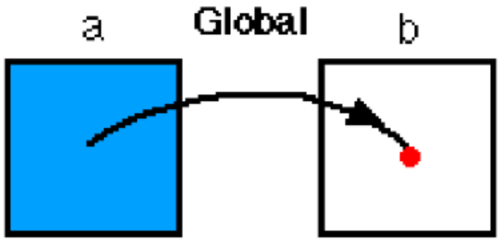
Center for Visual Information Technology (CVIT), IIIT Hyderabad

- Point to Point



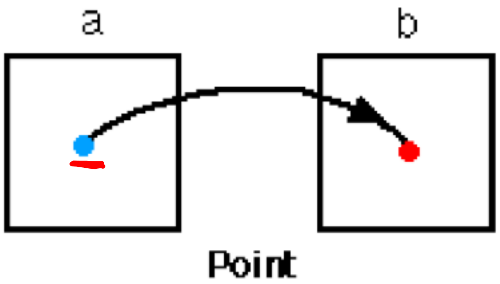
Intensity Transforms

- Global Attribute to Point



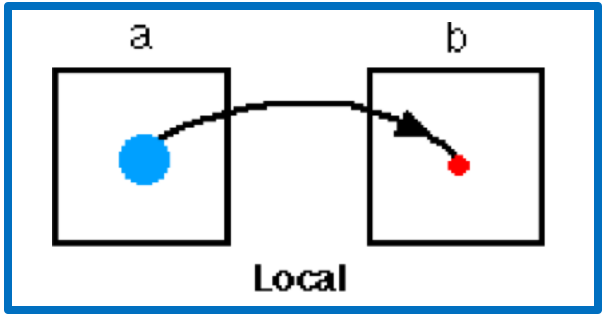
Histogram Equalization

- Point to Point

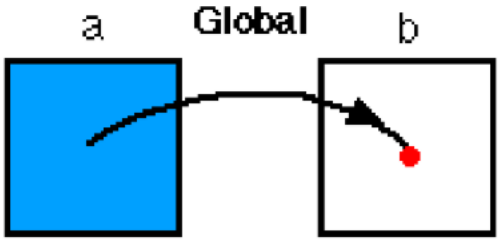


Intensity Transforms

- **Neighborhood to Point**

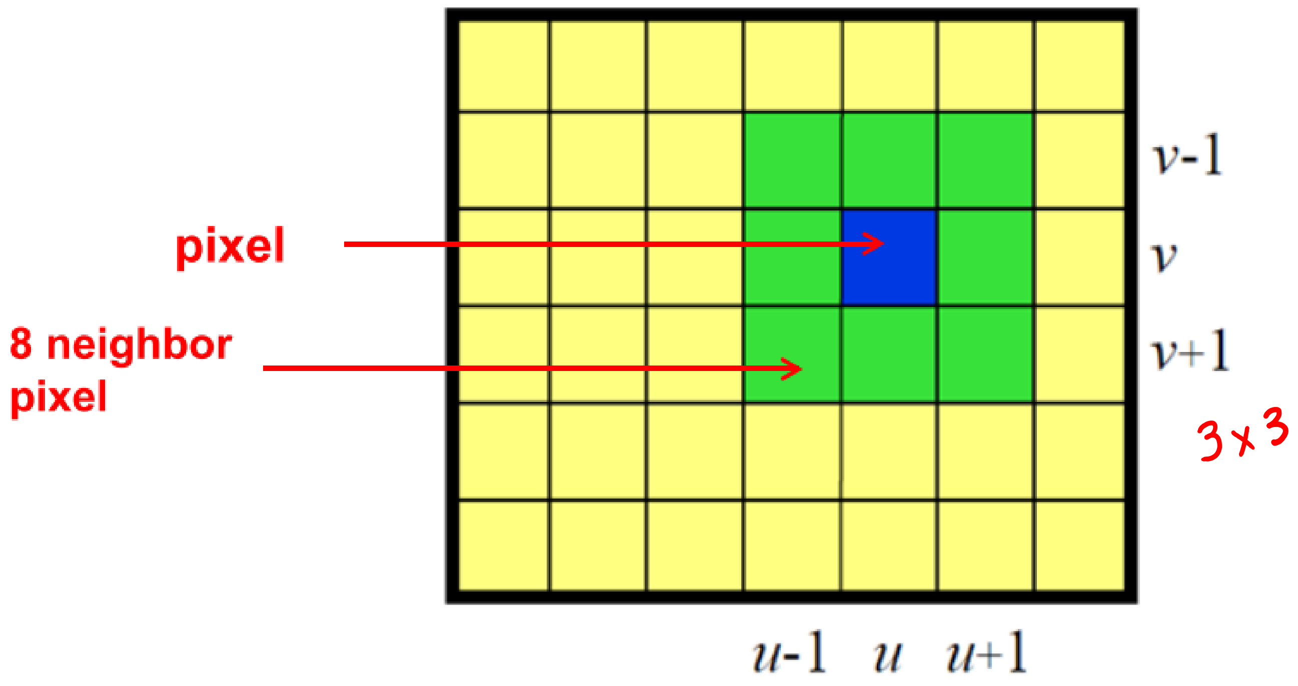


- Global Attribute to Point

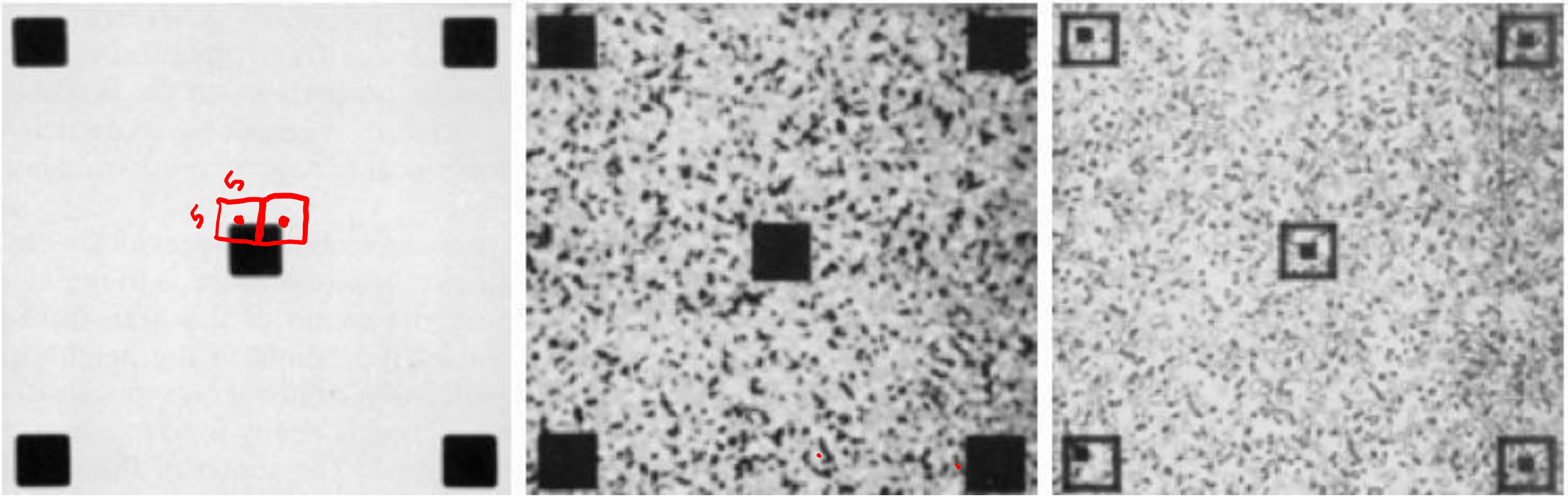


Histogram Equalization

Neighborhood



Local Histogram Processing



Global Hist Eq

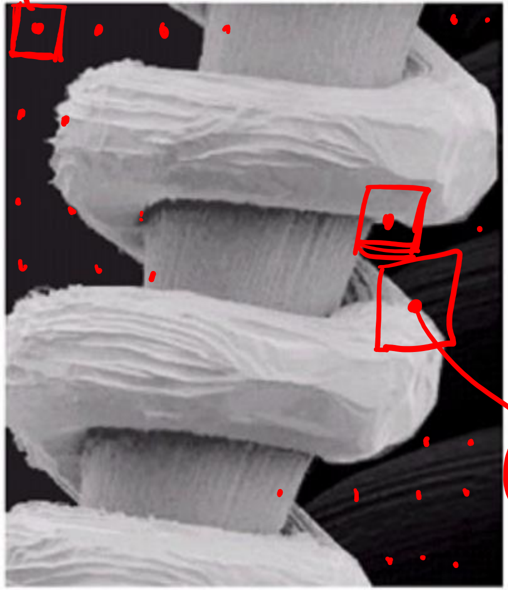
Local Hist Eq

5, 5, 5, 3, 7

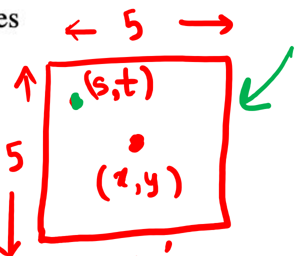
Image Courtesy: Gonzalez and Woods

$\boxed{1}$ $m_{S_{xy}} < k_1\, m(r)$

Conditional Image Enhancement



- Objective for given image: Enhance dark areas while leaving light areas unchanged
  - we use some statistical parameters
    - global:
      - $p(r_i) = \frac{n_i}{n}$
      - $m(r) = \sum_{i=0}^{L-1} p(r_i)\, r_i$
      - $\sigma^2(r) = \sum_{i=0}^{L-1} (r_i - m)^2\, p(r_i)$
    - local:
      - $p(r_{s,t})$: neighborhood normalized histogram at coordinates (s,t) using a mask centered at (x,y)
      - $m_{S_{xy}} = \sum_{(s,t)\in S_{xy}} p(r_{s,t})\, r_{s,t}$
      - $\sigma^2(S_{xy}) = \sum_{(s,t)\in S_{xy}} [r_{s,t} - m_{S_{xy}}]^2\, p(r_{s,t})$



$k_3\, \sigma(r) < \sigma_{S_{xy}} \le k_2\, \sigma(r)$ $\quad k_2 < 1$ $\boxed{2}$

1) Identify 'dark' ~~pixels~~ area, & 'light' pixels unchanged
2) Enhance dark ~~pixels~~ area

Image Enhancement Using Histogram Statistics

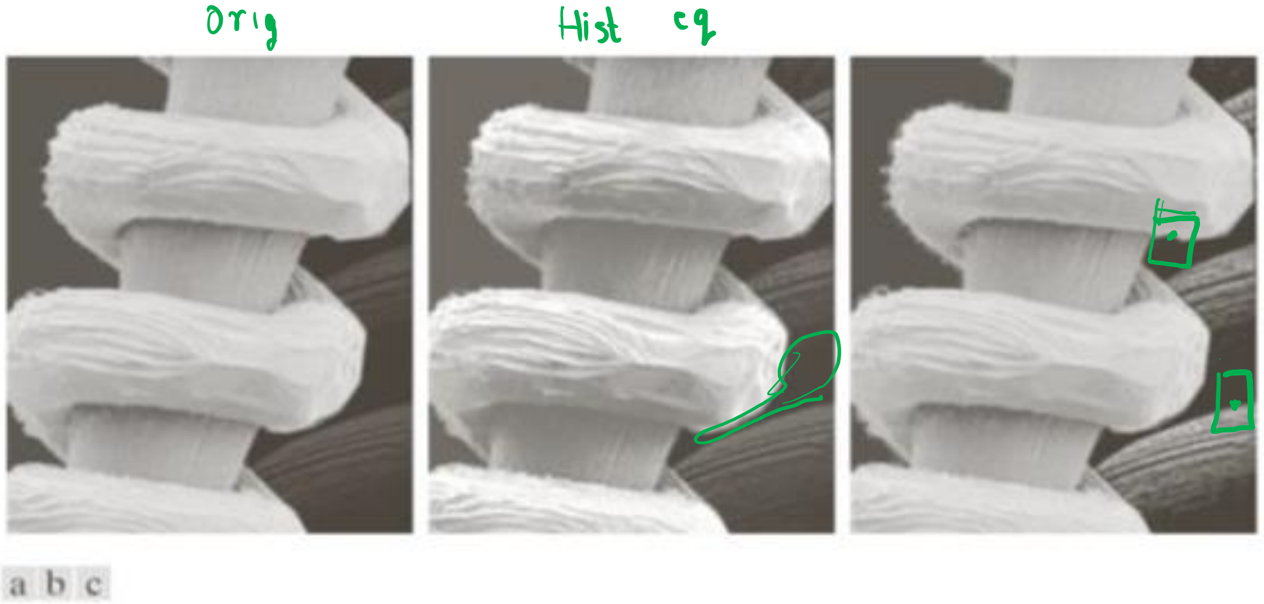


FIGURE 3.27 (a) SEM image of a tungsten filament magnified approximately 130×. (b) Result of global histogram equalization. (c) Image enhanced using local histogram statistics. (Original image courtesy of Mr. Michael Shaffer, Department of Geological Sciences, University of Oregon, Eugene.)

Scribe List

2018101010
2018101015
2018101019
2018101021
2018101022
2018101028