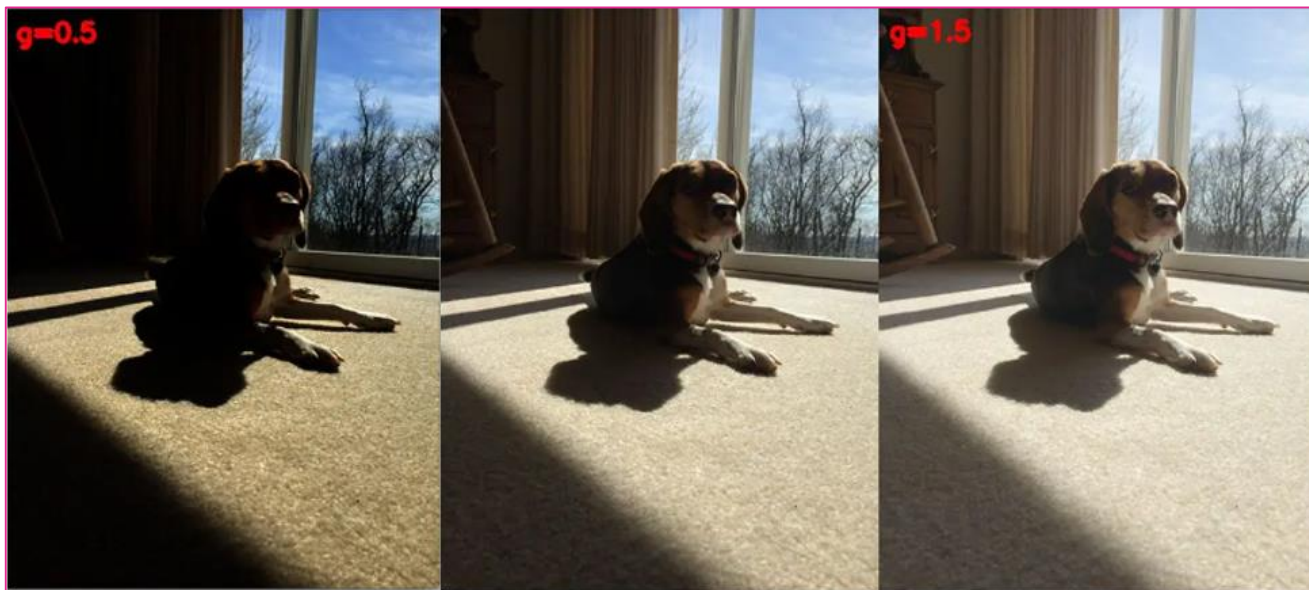


Image Enhancement:

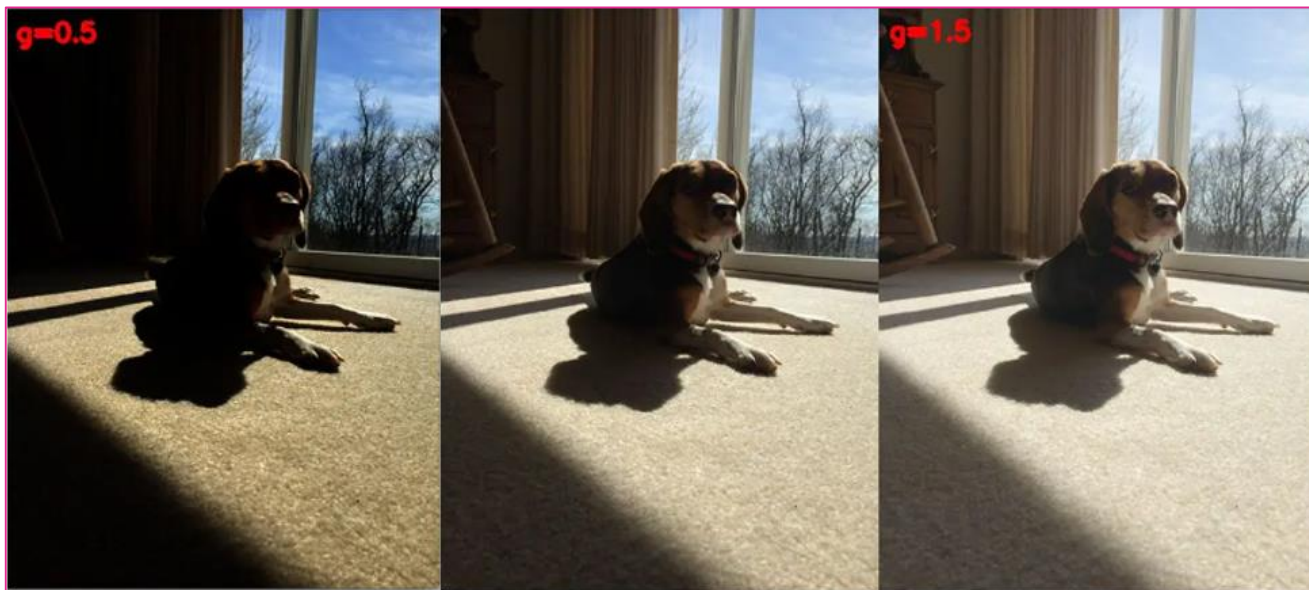
Spatial domain

Dr. Tushar Sandhan

Introduction

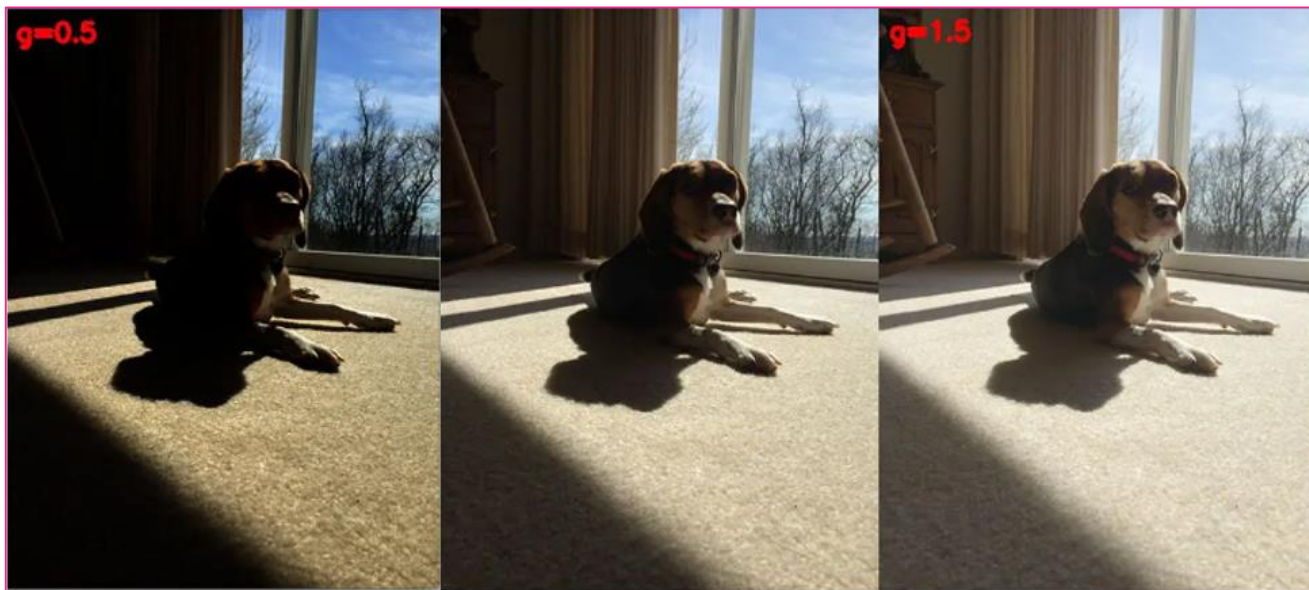


Introduction



Introduction

- Intensity transformations



- Distribution transformation



Spatial domain enhancements

- Transformations

- intensity transformations

- negatives
 - logs
 - power-law (gamma)
 - contrast stretching
 - level slicing
 - bit-plane slicing

- distribution transformations

- histogram equalization

- Spatial filtering

- image filtering

Spatial domain enhancements

■ Transformations

○ intensity transformations

- negatives
- logs
- power-law (gamma)
- contrast stretching
- level slicing
- bit-plane slicing

○ distribution transformations

- histogram equalization

■ Spatial filtering

○ image filtering

$$g(x, y) = T_i(f(x, y))$$

Spatial domain enhancements

■ Transformations

○ intensity transformations

- negatives
- logs
- power-law (gamma)
- contrast stretching
- level slicing
- bit-plane slicing

○ distribution transformations

- histogram equalization

■ Spatial filtering

○ image filtering

$$g(x, y) = T_i(f(x, y))$$



$$s \leftarrow r$$

Spatial domain enhancements

■ Transformations

○ intensity transformations

- negatives
- logs
- power-law (gamma)
- contrast stretching
- level slicing
- bit-plane slicing

○ distribution transformations

- histogram equalization

■ Spatial filtering

○ image filtering

$$g(x, y) = T_i(f(x, y))$$



$$s \leftarrow r$$

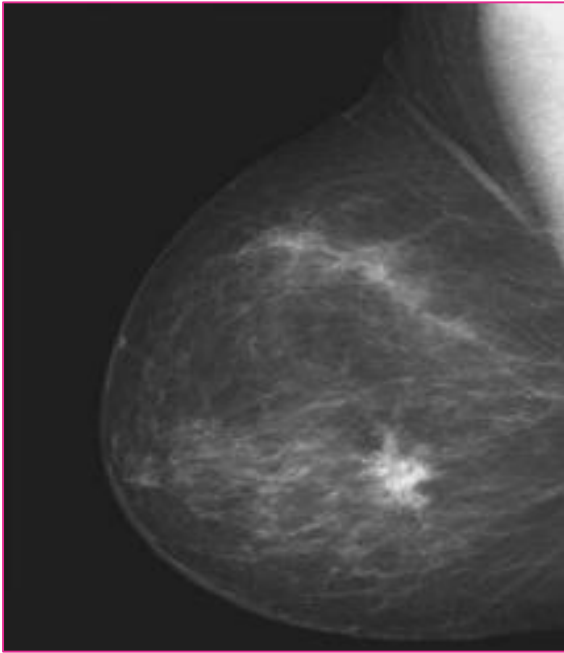
$$g(x, y) = T_i(p(f(x, y)))$$

Negatives

$$s = L - 1 - r$$

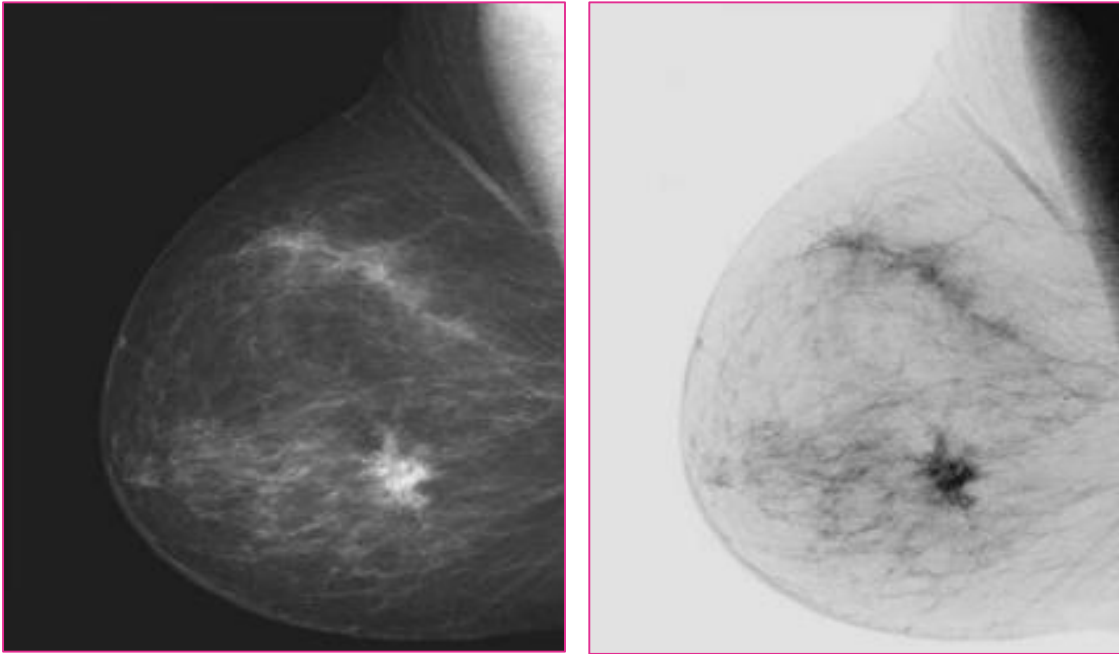
Negatives

$$s = L - 1 - r$$



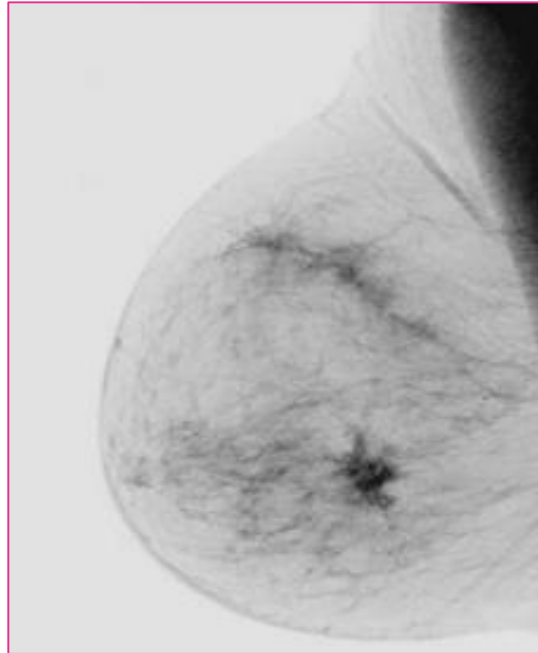
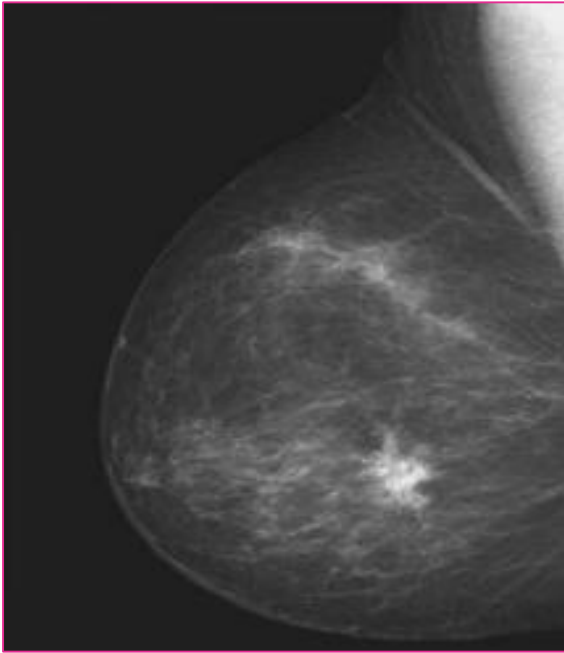
Negatives

$$s = L - 1 - r$$



Negatives

$$s = L - 1 - r$$



Logs

$$s = c \cdot \log(1 + r)$$

- Log transformations

- used to expand values of dark pixels
- simultaneously compressing bright pixels
- compresses dynamic range of images
 - Fourier spectrum

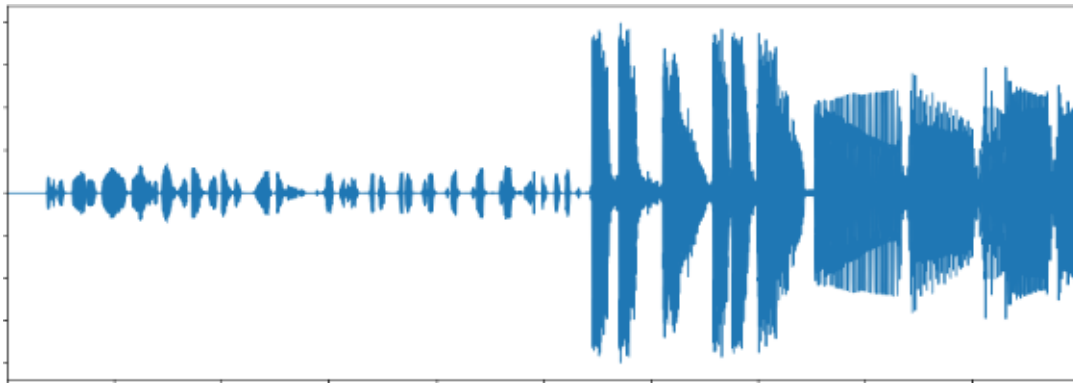


Logs

$$s = c \cdot \log(1 + r)$$

- Log transformations

- used to expand values of dark pixels
- simultaneously compressing bright pixels
- compresses dynamic range of images
 - Fourier spectrum

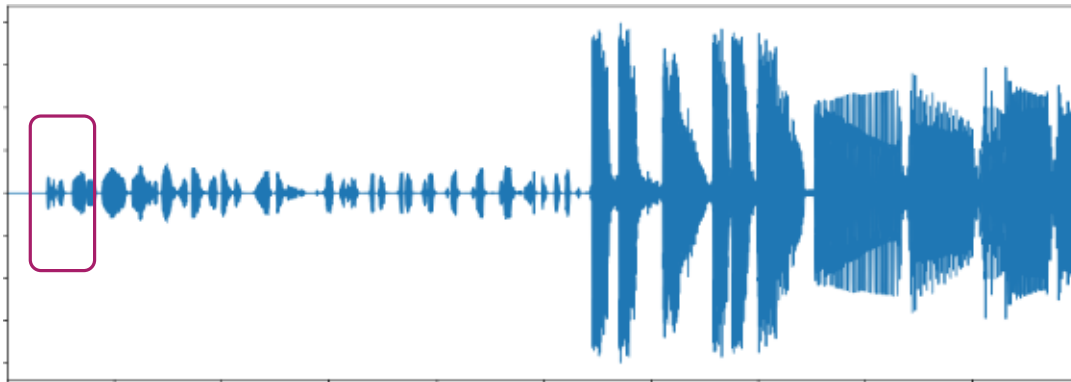


Logs

$$s = c \cdot \log(1 + r)$$

- Log transformations

- used to expand values of dark pixels
- simultaneously compressing bright pixels
- compresses dynamic range of images
 - Fourier spectrum

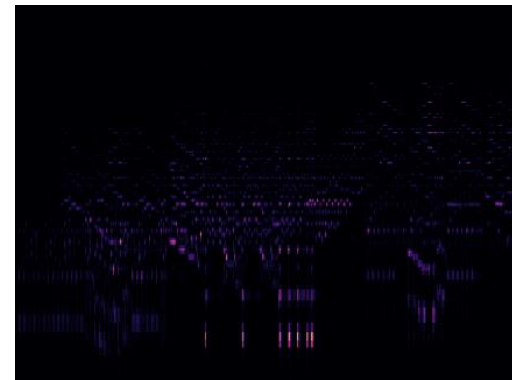
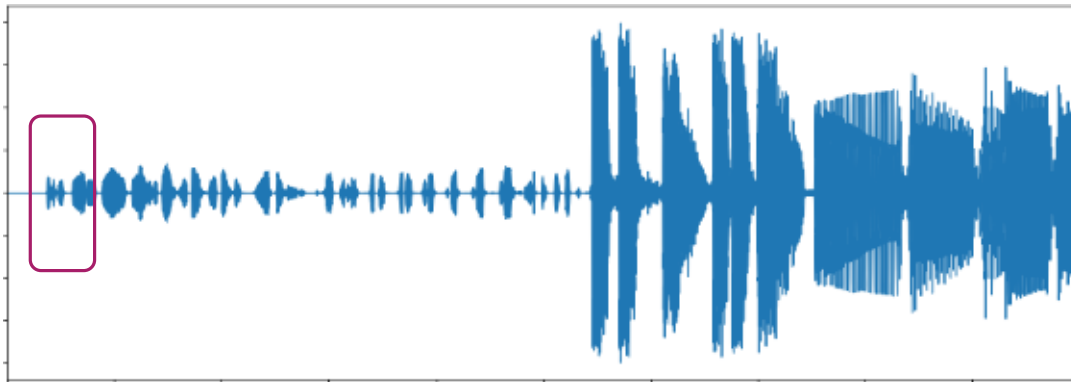


Logs

$$s = c \cdot \log(1 + r)$$

■ Log transformations

- used to expand values of dark pixels
- simultaneously compressing bright pixels
- compresses dynamic range of images
 - Fourier spectrum

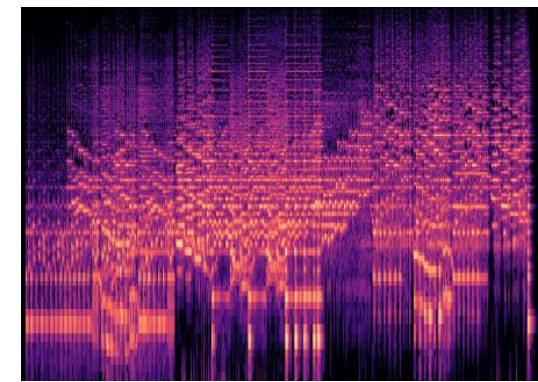
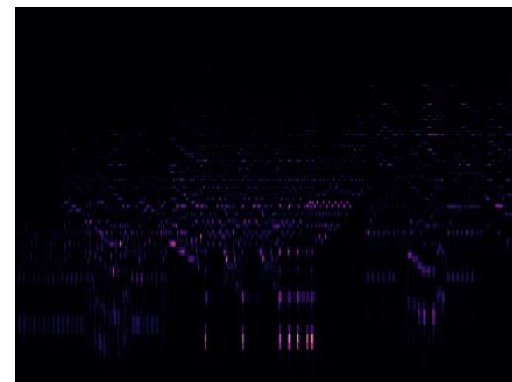
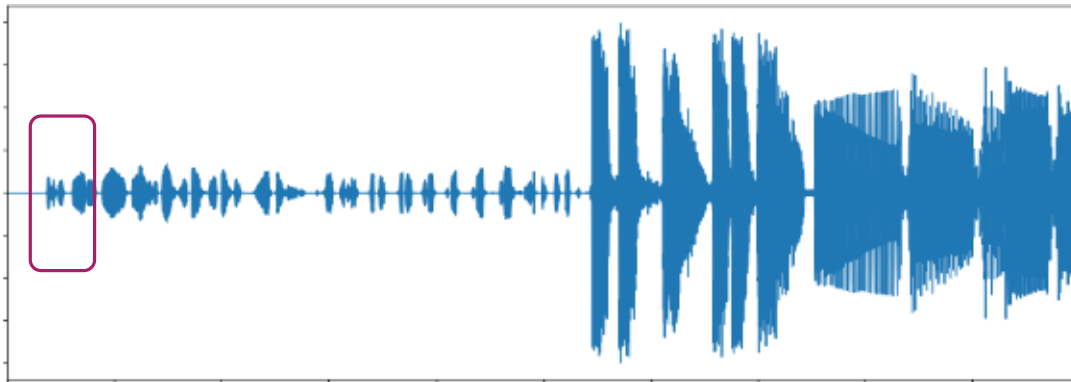


Logs

$$s = c \cdot \log(1 + r)$$

■ Log transformations

- used to expand values of dark pixels
- simultaneously compressing bright pixels
- compresses dynamic range of images
 - Fourier spectrum



Gammas

$$s = c \cdot r^\gamma$$

- Power-law transformations

- sensors respond according to power law
 - CMOS, scanners, printing, displays
 - CRT: intensity to voltage response as power function ($\gamma' = 1.8 \sim 2.5$)
- gamma correction
 - device dependent γ
 - γ variation also varies the color ratios
 - correct color reproduction needs knowledge of γ
- gamma injection
 - post image processing for contrast manipulation

Gammas

$$s = c \cdot r^\gamma$$

■ Power-law transformations

○ sensors respond according to power law

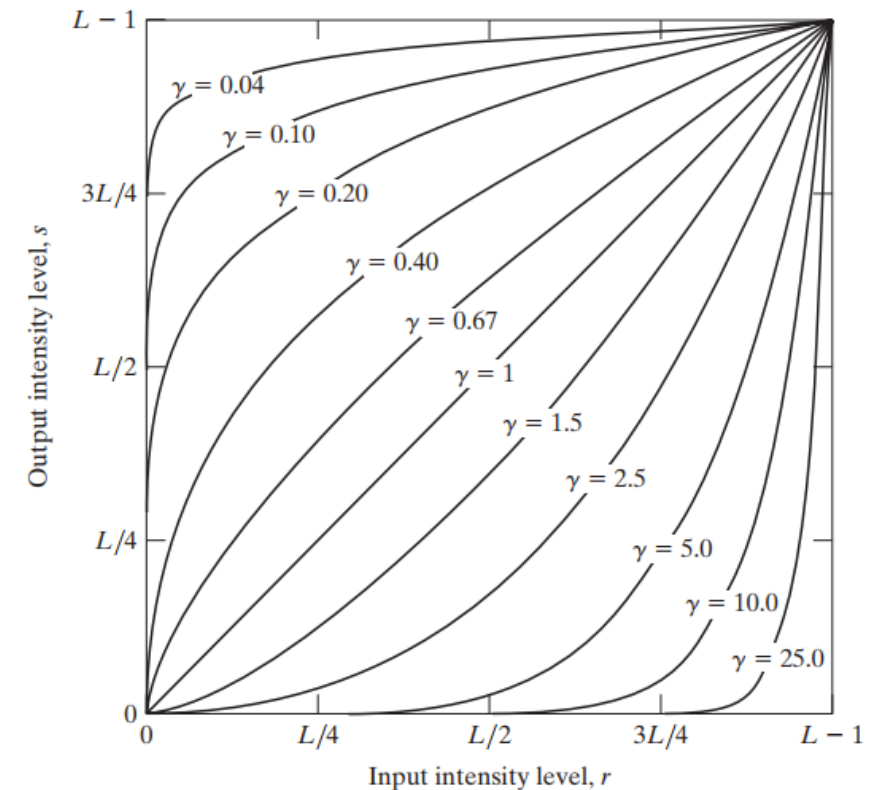
- CMOS, scanners, printing, displays
- CRT: intensity to voltage response as power function ($\gamma' = 1.8 \sim 2.5$)

○ gamma correction

- device dependent γ
- γ variation also varies the color ratios
- correct color reproduction needs knowledge of γ

○ gamma injection

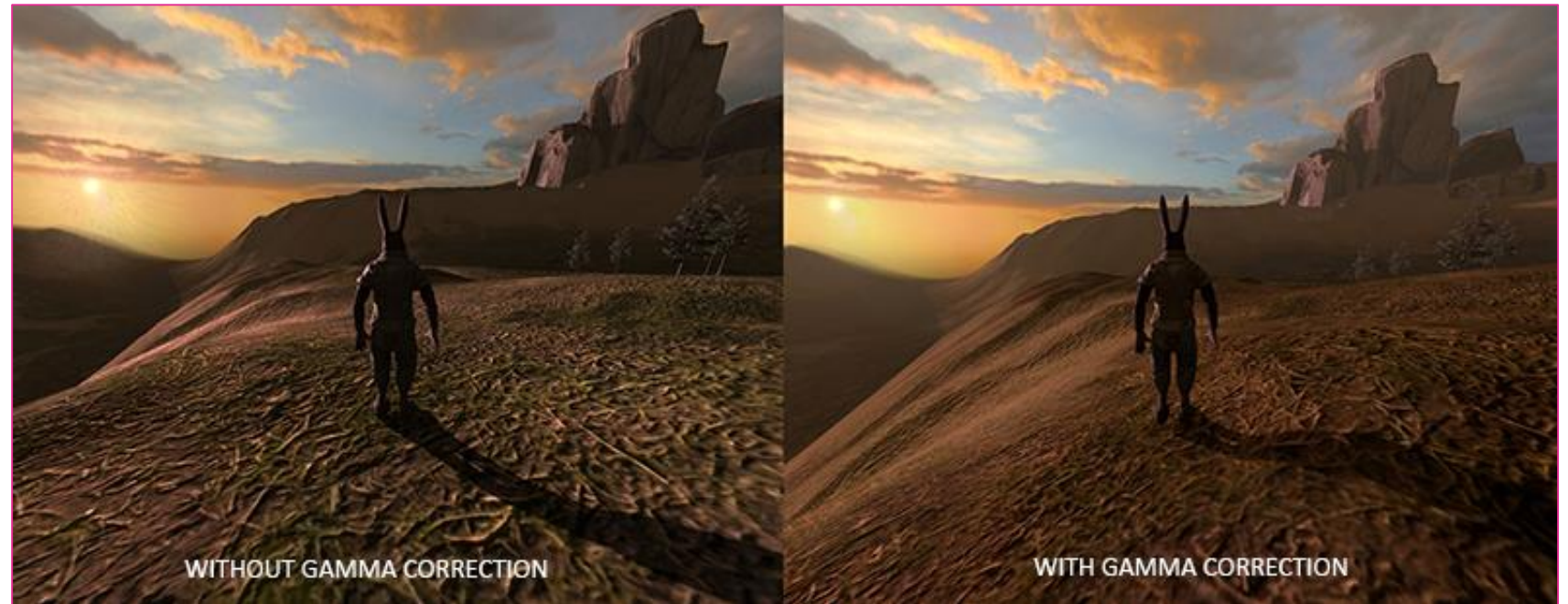
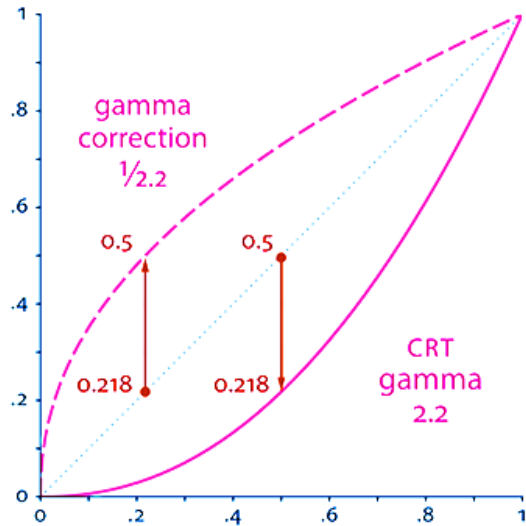
- post image processing for contrast manipulation



Gammas

$$s = c \cdot r^\gamma$$

■ γ correction



credit: blog.wolfire.com

Gammas

$$s = c \cdot r^\gamma$$

- γ injection



Gammas

$$s = c \cdot r^\gamma$$

- γ injection

1.0



0.6



0.4



0.3



Gammas

$$s = c \cdot r^\gamma$$

- γ injection

1.0



0.6



0.4



0.3



Gammas

$$s = c \cdot r^\gamma$$

■ γ injection

1.0



0.6



0.4



0.3



1.0



3.0



4.0



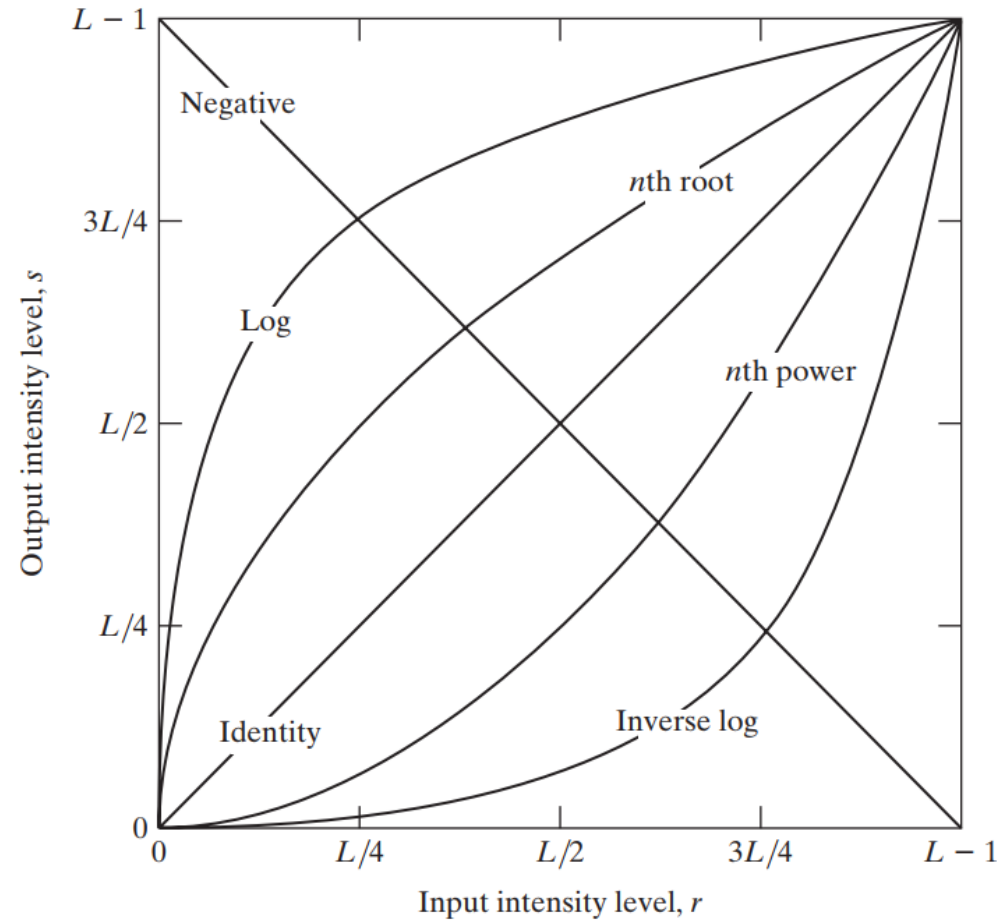
5.0



Transformations

■ Compositions

- piecewise combinations
- piecewise linear
 - many T_i formulated with this
 - need more user input paras



Contrast stretching

- Contrast

- low contrast images

- due to poor illumination, low dynamic range sensors
 - wrong setting of lens aperture

- full range stretching

- $(r_1, s_1) = (r_{min}, 0)$
 - $(r_2, s_2) = (r_{max}, L - 1)$

- thresholding

-



Contrast stretching

- Contrast

- low contrast images

- due to poor illumination, low dynamic range sensors
 - wrong setting of lens aperture

- full range stretching

- $(r_1, s_1) = (r_{min}, 0)$
 - $(r_2, s_2) = (r_{max}, L - 1)$

- thresholding

-



70~140

0~255

pixel ranges

Contrast stretching

■ Contrast

○ low contrast images

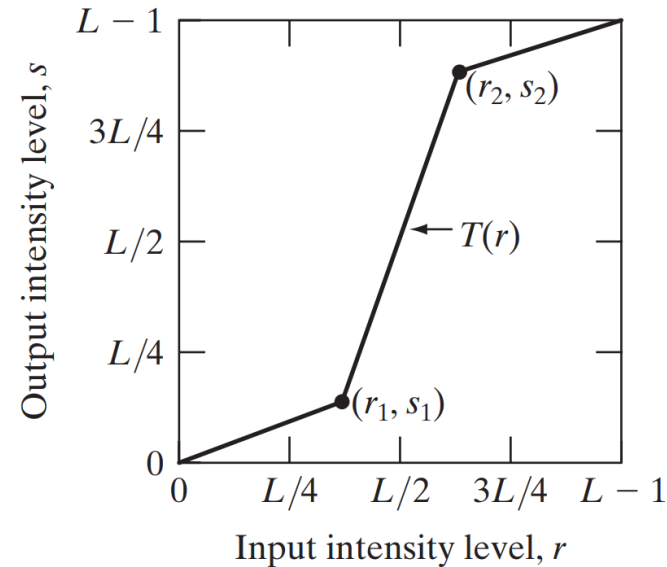
- due to poor illumination, low dynamic range sensors
- wrong setting of lens aperture

○ full range stretching

- $(r_1, s_1) = (r_{min}, 0)$
- $(r_2, s_2) = (r_{max}, L - 1)$

○ thresholding

-



70~140



0~255

pixel ranges

Contrast stretching

■ Contrast

○ low contrast images

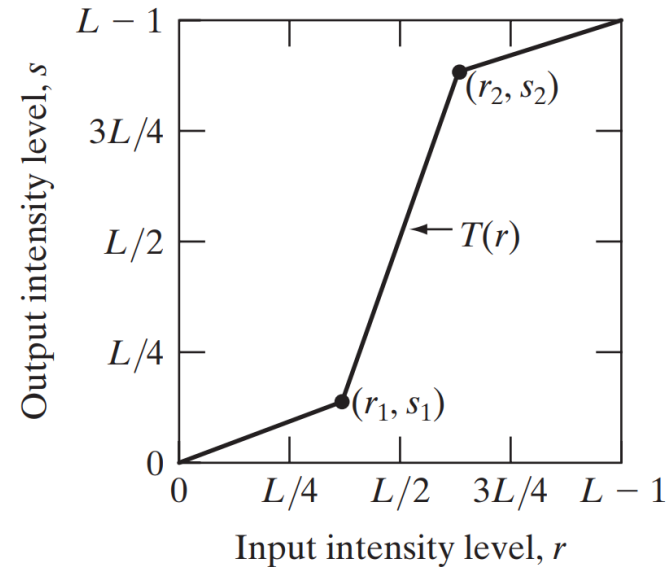
- due to poor illumination, low dynamic range sensors
- wrong setting of lens aperture

○ full range stretching

- $(r_1, s_1) = (r_{min}, 0)$
- $(r_2, s_2) = (r_{max}, L - 1)$

○ thresholding

- $r_1 = r_2, s_1 = 0, s_2 = L - 1$



70~140



0~255

pixel ranges

Contrast stretching

■ Contrast

○ low contrast images

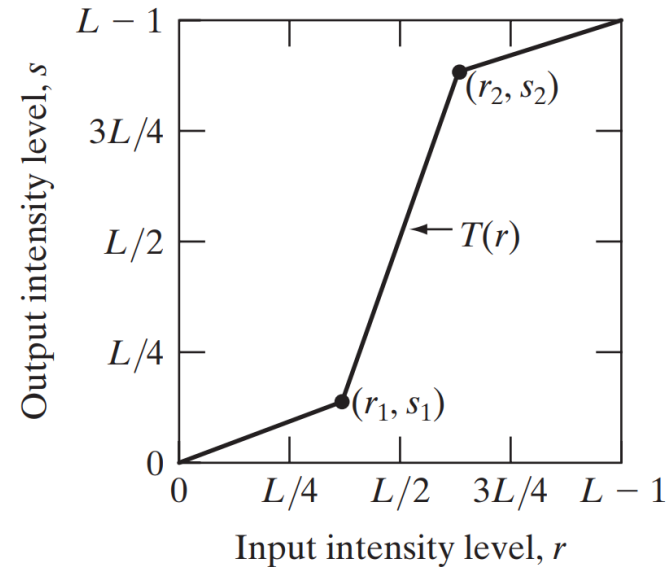
- due to poor illumination, low dynamic range sensors
- wrong setting of lens aperture

○ full range stretching

- $(r_1, s_1) = (r_{min}, 0)$
- $(r_2, s_2) = (r_{max}, L - 1)$

○ thresholding

- $r_1 = r_2, s_1 = 0, s_2 = L - 1$

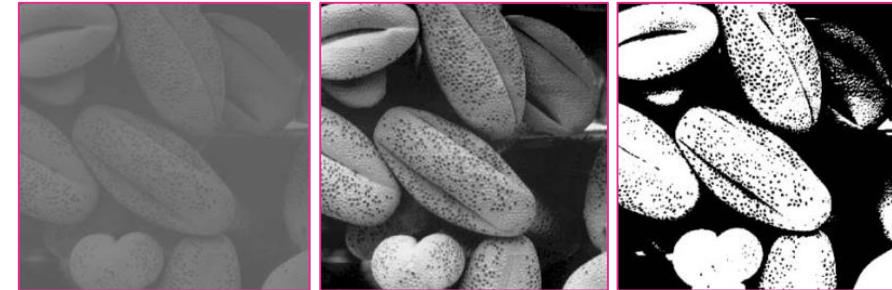


70~140



0~255

pixel ranges



Contrast stretching

■ Contrast

○ low contrast images

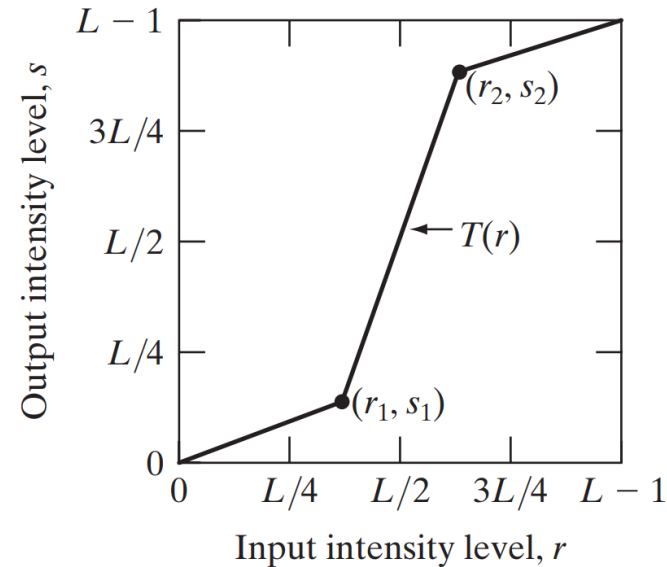
- due to poor illumination, low dynamic range sensors
- wrong setting of lens aperture

○ full range stretching

- $(r_1, s_1) = (r_{min}, 0)$
- $(r_2, s_2) = (r_{max}, L - 1)$

○ thresholding

- $r_1 = r_2, s_1 = 0, s_2 = L - 1$



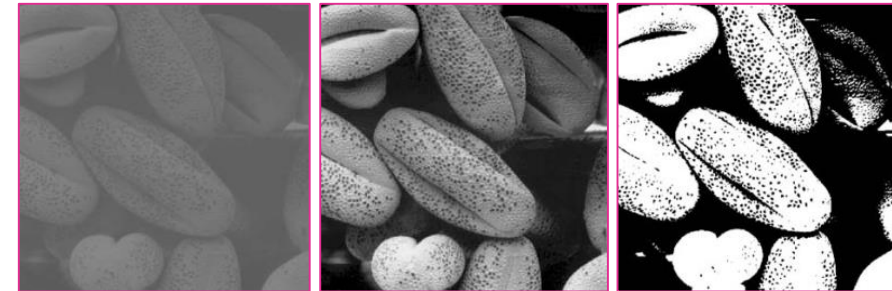
70~140



0~255

pixel ranges

SEM image of pollen grains



Level slicing

- Intensity levels
 - local thresholding, stretching
 - enhancing only specific intensities
 - e.g. detecting water, wetland in sat. images

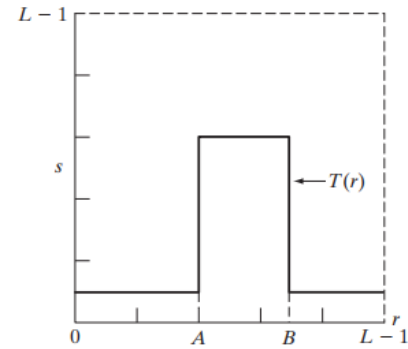
Level slicing

- Intensity levels
 - local thresholding, stretching
 - enhancing only specific intensities
 - e.g. detecting water, wetland in sat. images



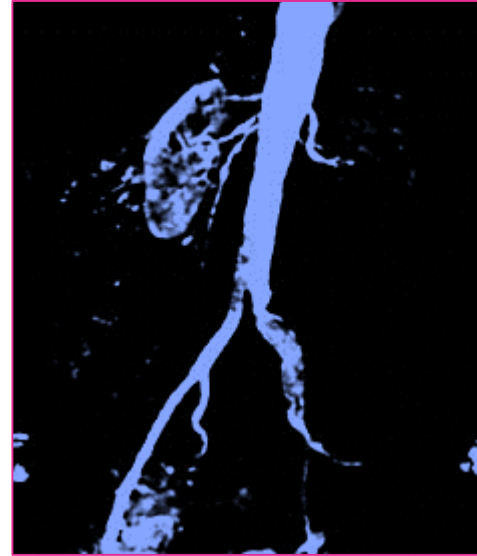
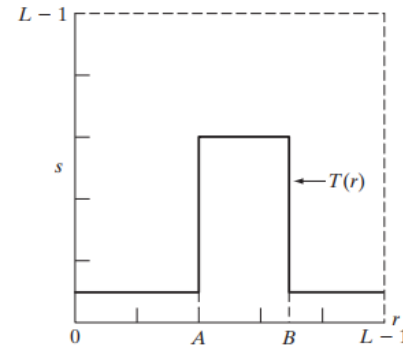
Level slicing

- Intensity levels
 - local thresholding, stretching
 - enhancing only specific intensities
 - e.g. detecting water, wetland in sat. images



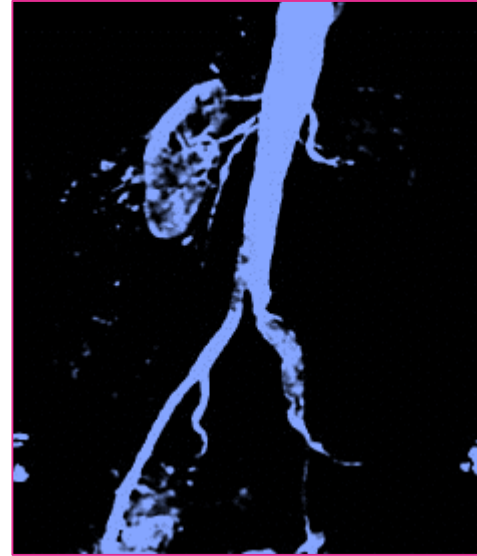
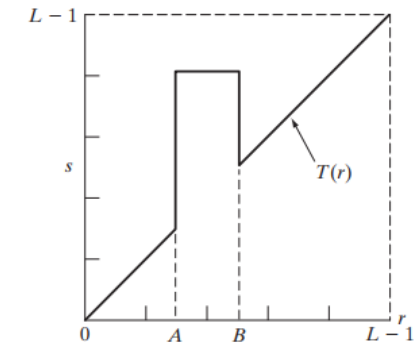
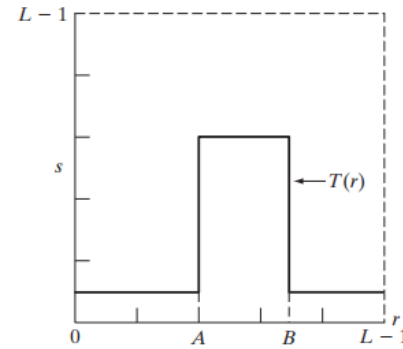
Level slicing

- Intensity levels
 - local thresholding, stretching
 - enhancing only specific intensities
 - e.g. detecting water, wetland in sat. images



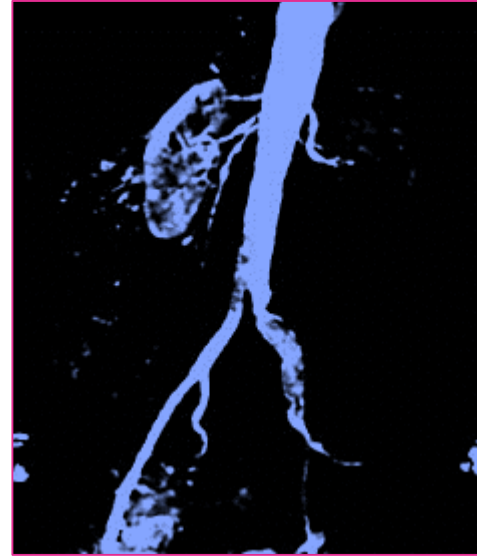
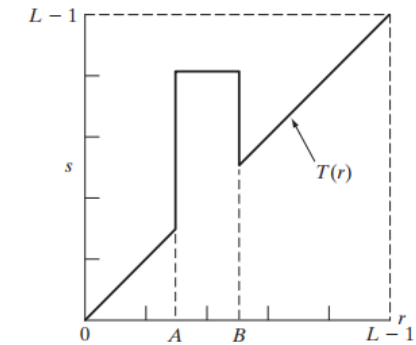
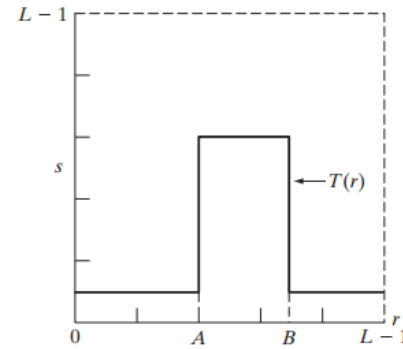
Level slicing

- Intensity levels
 - local thresholding, stretching
 - enhancing only specific intensities
 - e.g. detecting water, wetland in sat. images



Level slicing

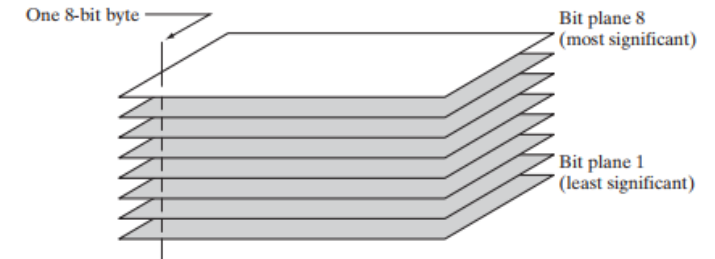
- Intensity levels
 - local thresholding, stretching
 - enhancing only specific intensities
 - e.g. detecting water, wetland in sat. images



Bitplane slicing

- Bitplanes

- contribution of each bit for total image appearance
- gives clue for a compression

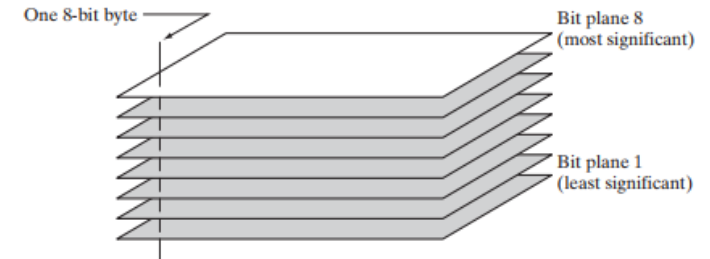


Bitplane slicing

- Bitplanes

- contribution of each bit for total image appearance
- gives clue for a compression

- slicing

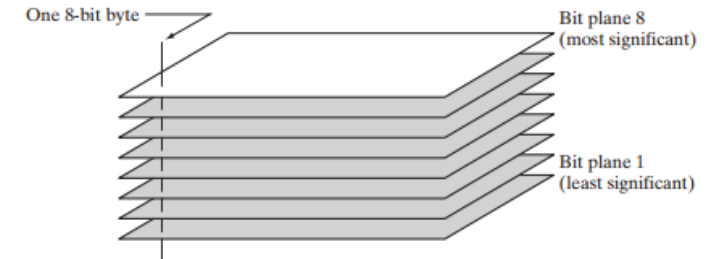


Bitplane slicing

- Bitplanes

- contribution of each bit for total image appearance
- gives clue for a compression

- slicing

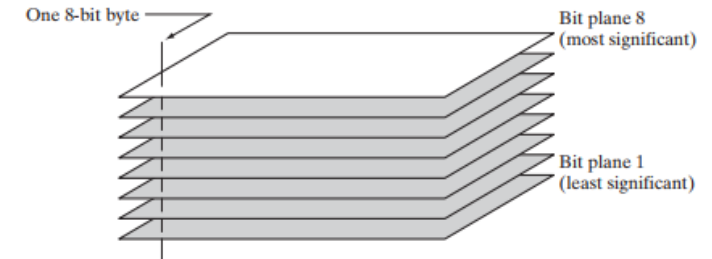


- reconstruction

Bitplane slicing

- Bitplanes

- contribution of each bit for total image appearance
- gives clue for a compression



- slicing



- reconstruction

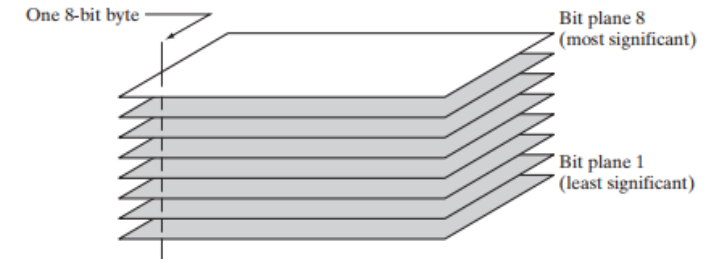


- bitplanes (8+7)

Bitplane slicing

- Bitplanes

- contribution of each bit for total image appearance
- gives clue for a compression



- slicing



- reconstruction

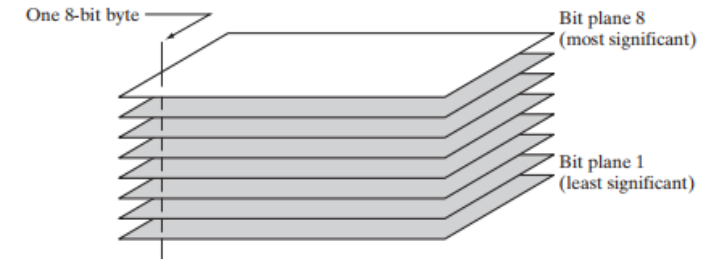


- bitplanes (8+7)
- bitplanes (8+7+6)

Bitplane slicing

- Bitplanes

- contribution of each bit for total image appearance
- gives clue for a compression



- slicing



- reconstruction



- bitplanes (8+7)
- bitplanes (8+7+6)
- bitplanes (8+7+6+5)

Spatial domain enhancements

■ Transformations

○ intensity transformations

- negatives
- logs
- power-law (gamma)
- contrast stretching
- level slicing
- bit-plane slicing

○ distribution transformations

- histogram equalization

■ Spatial filtering

○ image filtering

$$g(x, y) = T_i(f(x, y))$$



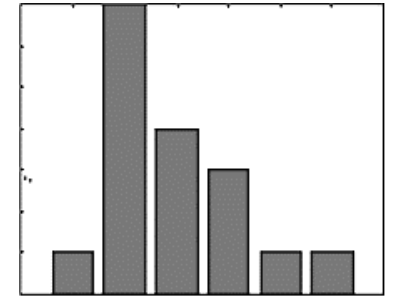
$$s \leftarrow r$$

$$g(x, y) = T_i(p(f(x, y)))$$

Histograms

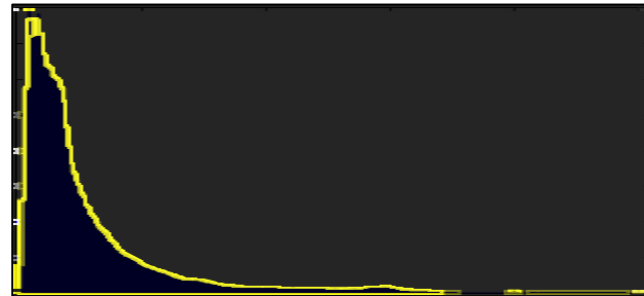
- distribution of discrete intensities
 - distribution is also discrete

4	1	3	2
3	1	1	1
0	1	5	2
1	1	2	2

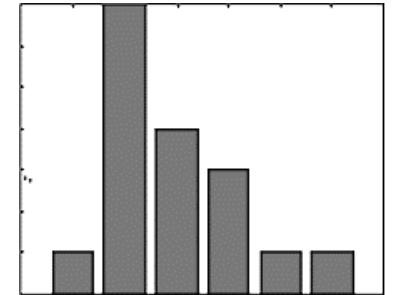


Histograms

- distribution of discrete intensities
 - distribution is also discrete



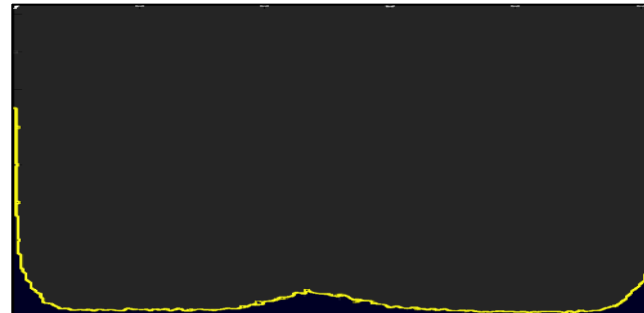
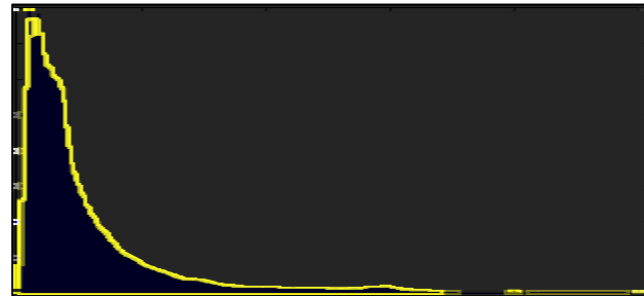
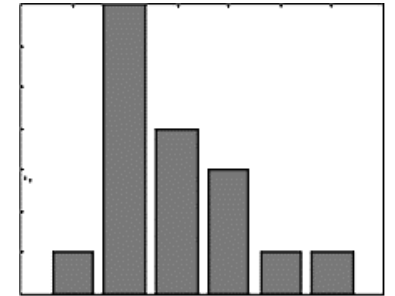
4	1	3	2
3	1	1	1
0	1	5	2
1	1	2	2



Histograms

- distribution of discrete intensities
 - distribution is also discrete

4	1	3	2
3	1	1	1
0	1	5	2
1	1	2	2



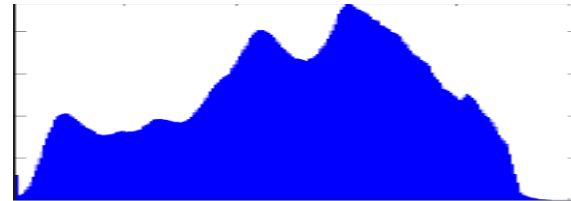
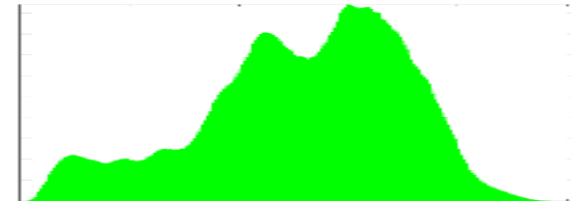
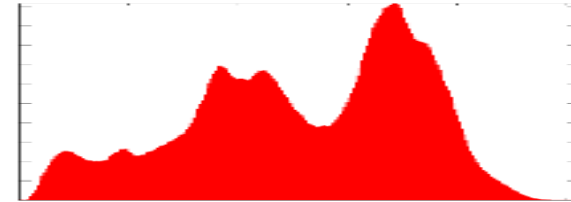
Histograms

- Color images



Histograms

- Color images

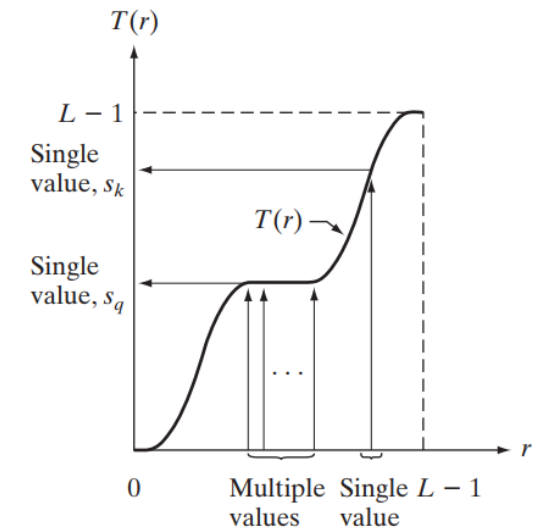
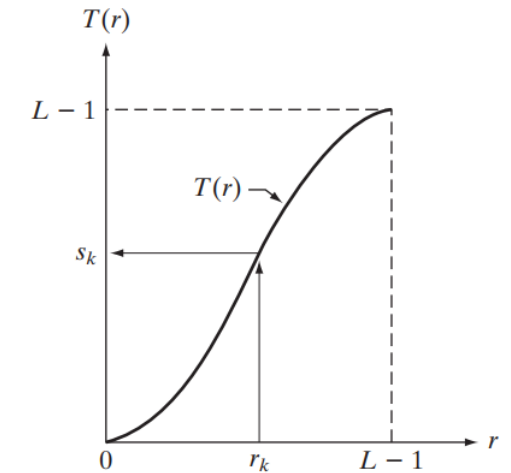


Histogram equalization

- Assume

- $T(r)$ is monotonic \uparrow
- bounded $0 \leq T(r) \leq L - 1$
- variable equivalence
 - to cover all notations

$$s = T(r) \quad 0 \leq r \leq L - 1$$

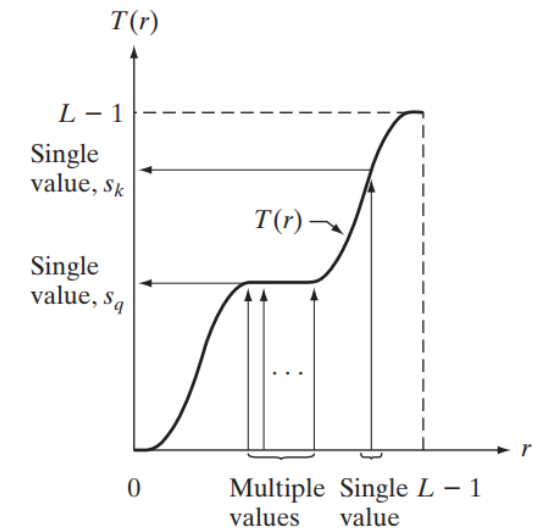
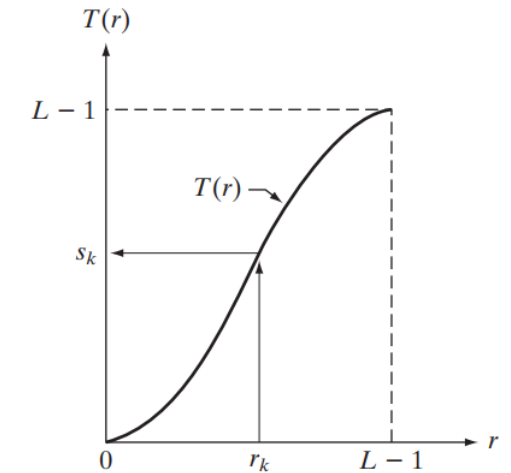


Histogram equalization

- Assume

- $T(r)$ is monotonic \uparrow
- bounded $0 \leq T(r) \leq L - 1$
- variable equivalence
 - to cover all notations


$$Y = T(X) \quad 0 \leq r \leq L - 1$$
$$s = T(r)$$

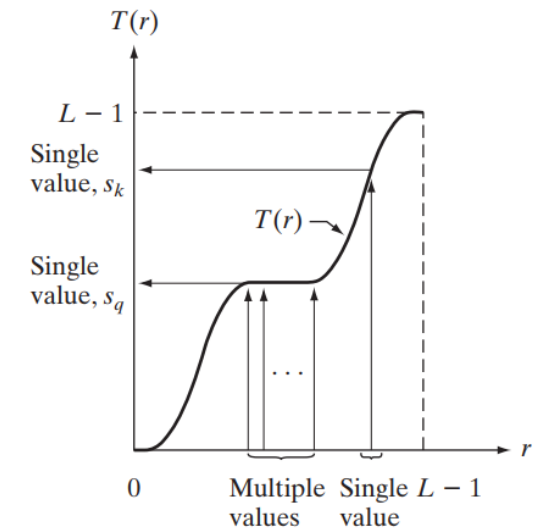
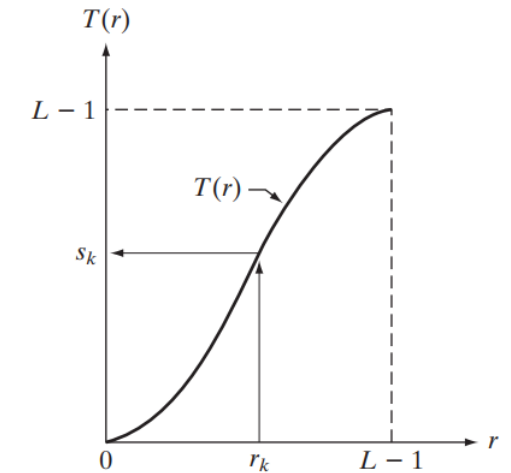


Histogram equalization

- Assume

- $T(r)$ is monotonic \uparrow
- bounded $0 \leq T(r) \leq L - 1$
- variable equivalence
 - to cover all notations

$$Y = T(X) \qquad 0 \leq r \leq L - 1$$
$$s = T(r)$$




Histogram equalization

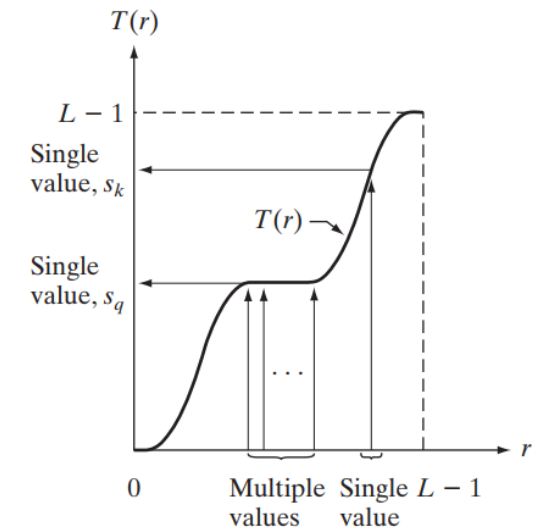
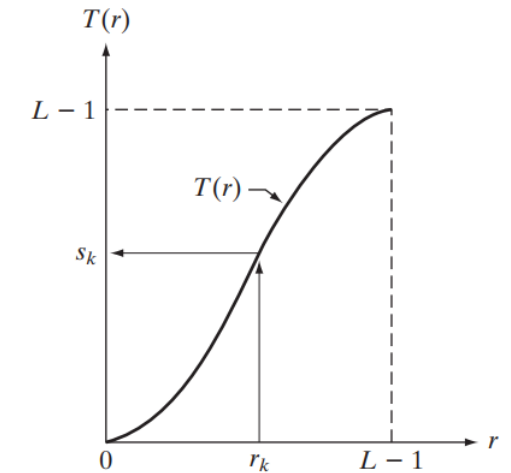
- Assume

- $T(r)$ is monotonic \uparrow
- bounded $0 \leq T(r) \leq L - 1$
- variable equivalence
 - to cover all notations

$$Y = T(X) \quad 0 \leq r \leq L - 1$$
$$s = T(r)$$

$\swarrow \quad \searrow$

$p_s(s) \quad p_r(r)$



Histogram equalization

- Assume

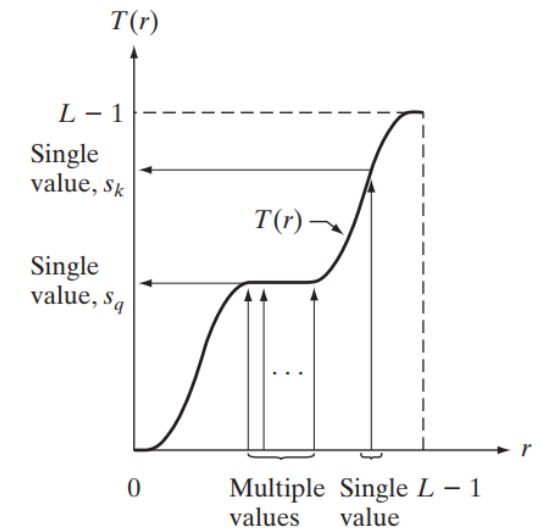
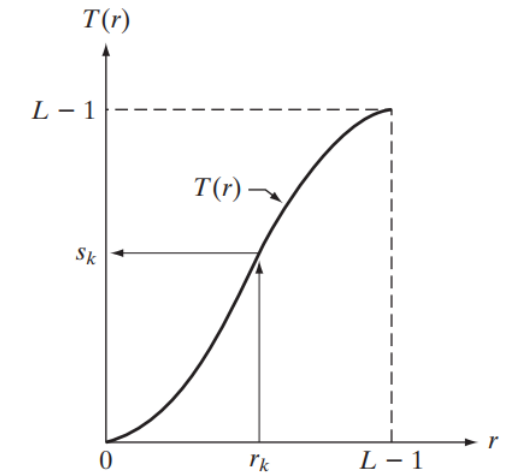
- $T(r)$ is monotonic \uparrow
- bounded $0 \leq T(r) \leq L - 1$
- variable equivalence
 - to cover all notations

$$Y = T(X) \quad 0 \leq r \leq L - 1$$

$$s = T(r)$$

$p_s(s)$
 $p_Y(y)$

$p_r(r)$
 $p_X(x)$



Histogram equalization

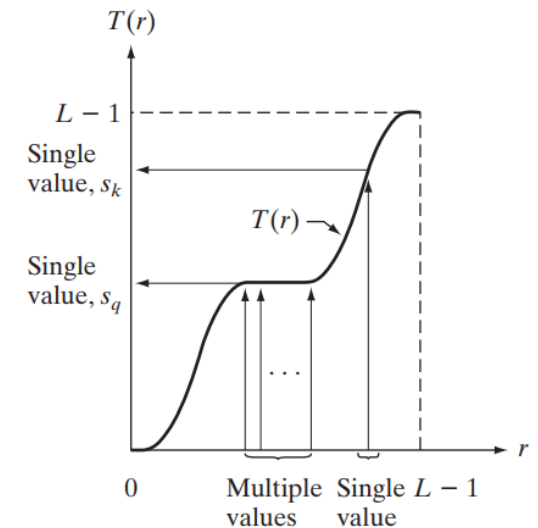
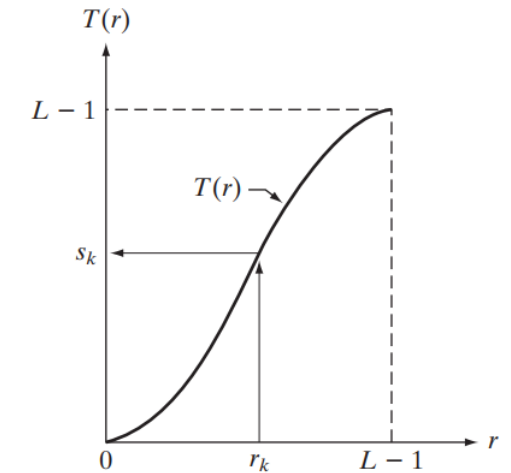
- Assume

- $T(r)$ is monotonic \uparrow
- bounded $0 \leq T(r) \leq L - 1$
- variable equivalence
 - to cover all notations

$$Y = T(X)$$
$$s = T(r)$$
$$\begin{array}{cc} \swarrow & \searrow \\ p_s(s) & p_r(r) \\ p_Y(y) & p_X(x) \end{array}$$

$$0 \leq r \leq L - 1$$

$T(r)$ is cts & differentiable



Histogram equalization

- Assume

- $T(r)$ is monotonic \uparrow
- bounded $0 \leq T(r) \leq L - 1$
- variable equivalence
 - to cover all notations

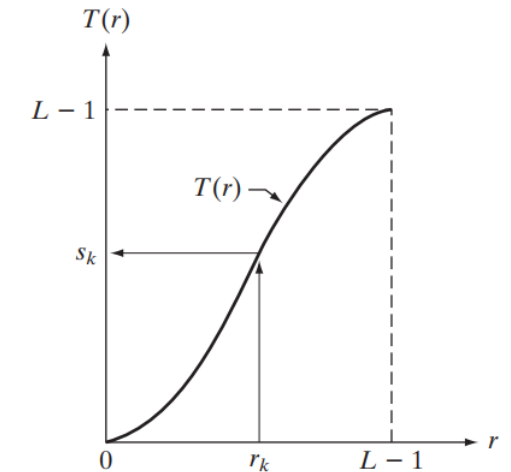
$$Y = T(X)$$

$$s = T(r)$$

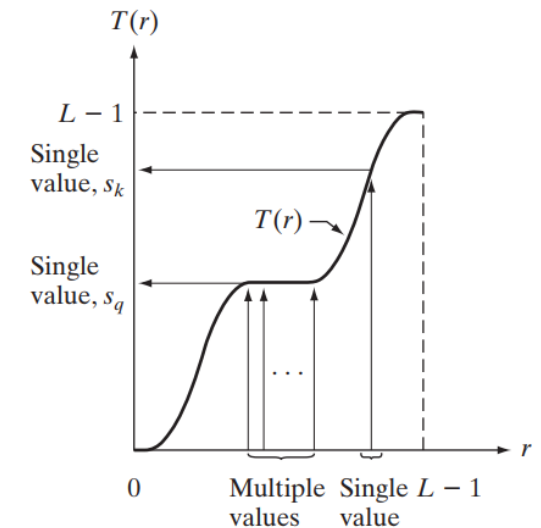
$$\begin{array}{cc} \swarrow & \searrow \\ p_s(s) & p_r(r) \\ p_Y(y) & p_X(x) \end{array}$$

$$0 \leq r \leq L - 1$$

$T(r)$ is cts & differentiable



- cumulative function satisfies above properties for $T(r)$



Histogram equalization

- Assume

- $T(r)$ is monotonic \uparrow
- bounded $0 \leq T(r) \leq L - 1$
- variable equivalence
 - to cover all notations

$$Y = T(X)$$

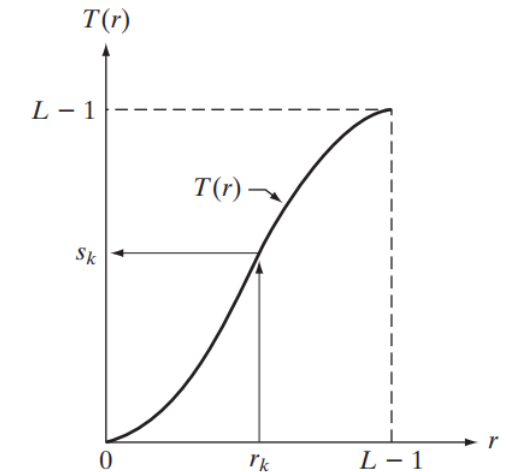
$$0 \leq r \leq L - 1$$

$$s = T(r)$$

$$T(r) \text{ is cts \& differentiable}$$

$p_s(s)$
 $p_Y(y)$

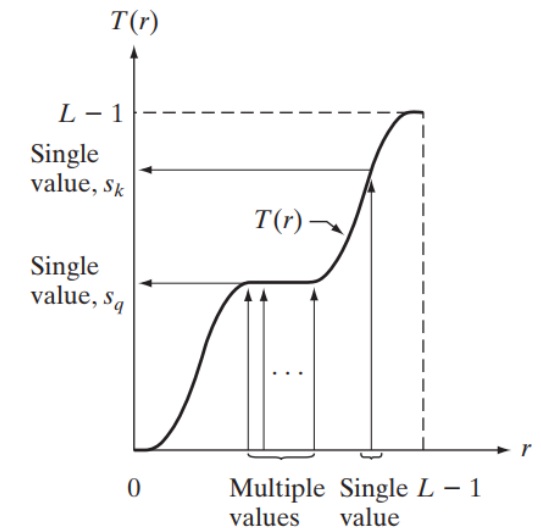
$p_r(r)$
 $p_X(x)$



- cumulative function satisfies above properties for $T(r)$

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

$$Y = T(X) = (L - 1) \int_0^X p_X(x) dx$$



Histogram equalization

- Assume

- $T(r)$ is monotonic \uparrow
- bounded $0 \leq T(r) \leq L - 1$
- variable equivalence
 - to cover all notations

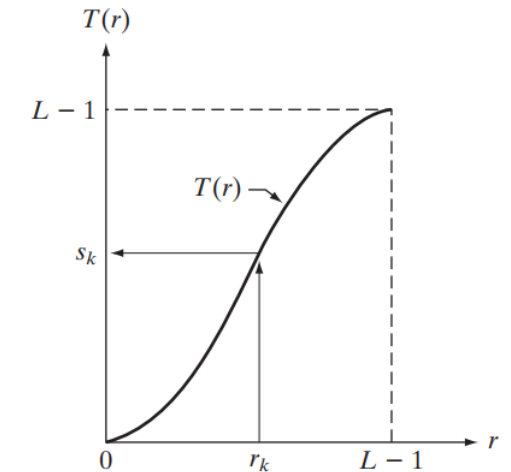
$$Y = T(X)$$

$$s = T(r)$$

$$\begin{array}{cc} \swarrow & \searrow \\ p_s(s) & p_r(r) \\ p_Y(y) & p_X(x) \end{array}$$

$$0 \leq r \leq L - 1$$

$T(r)$ is cts & differentiable



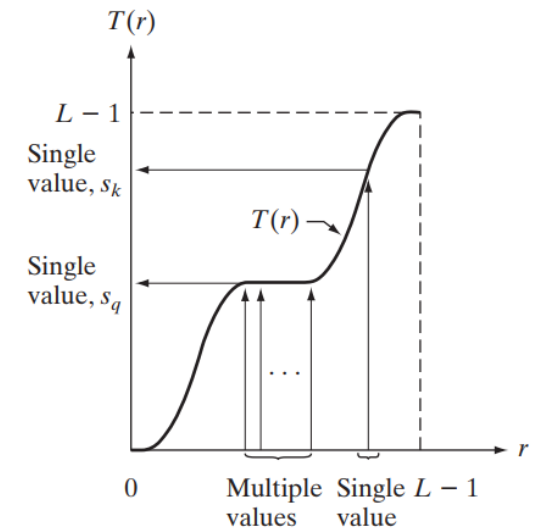
- cumulative function satisfies above properties for $T(r)$

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

$$= \frac{(L - 1)}{MN} \sum_{j=0}^k n_j \quad k = 0, 1, 2, \dots, L - 1$$

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

$$Y = T(X) = (L - 1) \int_0^X p_X(x) dx$$



Histogram equalization

$$Y = T(X) = (L - 1) \int_0^x p_X(x) dx$$

What is $p_Y(y)$?

$$\begin{array}{ccc} Y = T(X) & & \\ \swarrow & & \searrow \\ p_Y(y) & & p_X(x) \end{array}$$

$T(X)$ is cts & differentiable

Histogram equalization

$$Y = T(X) = (L - 1) \int_0^X p_X(x) dx$$

$$\begin{array}{ccc} Y = T(X) & & \\ \swarrow & & \searrow \\ p_Y(y) & & p_X(x) \end{array}$$

$T(X)$ is cts & differentiable

What is $p_Y(y)$?

$$\int_0^y p_Y(z) dz = \text{probability that } 0 \leq Y \leq y$$

Histogram equalization

$$Y = T(X) = (L - 1) \int_0^X p_X(x) dx$$

$$\begin{array}{ccc} Y = T(X) & & \\ \swarrow & & \searrow \\ p_Y(y) & & p_X(x) \end{array}$$

$T(X)$ is cts & differentiable

What is $p_Y(y)$?

$$\begin{aligned} \int_0^y p_Y(z) dz &= \text{probability that } 0 \leq Y \leq y \\ &= \text{probability that } 0 \leq X \leq T^{-1}(y) \end{aligned}$$

Histogram equalization

$$Y = T(X) = (L - 1) \int_0^X p_X(x) dx$$

$$\begin{array}{ccc} Y = T(X) & & \\ \swarrow & & \searrow \\ p_Y(y) & & p_X(x) \end{array}$$

$T(X)$ is cts & differentiable

What is $p_Y(y)$?

$$\int_0^y p_Y(z) dz = \text{probability that } 0 \leq Y \leq y$$

$$= \text{probability that } 0 \leq X \leq T^{-1}(y)$$

$$= \int_0^{T^{-1}(y)} p_X(w) dw$$

Histogram equalization

$$Y = T(X) = (L - 1) \int_0^X p_X(x) dx$$

$$\begin{array}{ccc} Y = T(X) & & \\ \swarrow & & \searrow \\ p_Y(y) & & p_X(x) \end{array}$$

$T(X)$ is cts & differentiable

What is $p_Y(y)$?

$$\int_0^y p_Y(z) dz = \int_0^{T^{-1}(y)} p_X(w) dw$$

Histogram equalization

$$Y = T(X) = (L - 1) \int_0^X p_X(x) dx$$

$$\begin{array}{ccc} Y = T(X) & & \\ \swarrow & & \searrow \\ p_Y(y) & & p_X(x) \end{array}$$

$T(X)$ is cts & differentiable

What is $p_Y(y)$?

$$\int_0^y p_Y(z) dz = \int_0^{T^{-1}(y)} p_X(w) dw$$

$$\frac{d}{dy} \left(\int_0^y p_Y(z) dz \right)$$

Histogram equalization

$$Y = T(X) = (L - 1) \int_0^X p_X(x) dx$$

$$\begin{array}{ccc} Y = T(X) & & \\ \swarrow & & \searrow \\ p_Y(y) & & p_X(x) \end{array}$$

$T(X)$ is cts & differentiable

What is $p_Y(y)$?

$$\int_0^y p_Y(z) dz = \int_0^{T^{-1}(y)} p_X(w) dw$$

$$\frac{d}{dy} \left(\int_0^y p_Y(z) dz \right) = p_X(T^{-1}(y)) \frac{d}{dy} (T^{-1}(y))$$

Histogram equalization

$$Y = T(X) = (L - 1) \int_0^X p_X(x) dx$$

$$\begin{array}{ccc} Y = T(X) & & \\ \swarrow & & \searrow \\ p_Y(y) & & p_X(x) \end{array}$$

$T(X)$ is cts & differentiable

What is $p_Y(y)$?

$$\int_0^y p_Y(z) dz = \int_0^{T^{-1}(y)} p_X(w) dw$$

$$\frac{d}{dy} \left(\int_0^y p_Y(z) dz \right) = p_X(T^{-1}(y)) \frac{d}{dy} (T^{-1}(y))$$

$$p_Y(y)$$

Histogram equalization

$$Y = T(X) = (L - 1) \int_0^X p_X(x) dx$$

$$\begin{array}{ccc} Y = T(X) & & \\ \swarrow & & \searrow \\ p_Y(y) & & p_X(x) \end{array}$$

$T(X)$ is cts & differentiable

What is $p_Y(y)$?

$$\int_0^y p_Y(z) dz = \int_0^{T^{-1}(y)} p_X(w) dw$$

$$\frac{d}{dy} \left(\int_0^y p_Y(z) dz \right) = p_X(T^{-1}(y)) \frac{d}{dy} (T^{-1}(y))$$

$$p_Y(y) = p_X(T^{-1}(y)) \frac{d}{dy} (T^{-1}(y))$$

Histogram equalization

$$Y = T(X) = (L - 1) \int_0^X p_X(x) dx$$

$$\begin{array}{ccc} Y = T(X) & & \\ \swarrow & & \searrow \\ p_Y(y) & & p_X(x) \end{array}$$

$T(X)$ is cts & differentiable

What is $p_Y(y)$?

$$p_Y(y) = p_X(T^{-1}(y)) \frac{d}{dy}(T^{-1}(y))$$

Histogram equalization

$$Y = T(X) = (L - 1) \int_0^X p_X(x) dx$$

$$\begin{array}{ccc} Y = T(X) & & \\ \swarrow & & \searrow \\ p_Y(y) & & p_X(x) \end{array}$$

$T(X)$ is cts & differentiable

What is $p_Y(y)$?

$$p_Y(y) = p_X(T^{-1}(y)) \frac{d}{dy}(T^{-1}(y))$$

$$= \frac{1}{L-1} \cdot \frac{dT}{dx} \Big|_{x=T^{-1}(y)} \frac{d}{dy}(T^{-1}(y))$$

Histogram equalization

$$Y = T(X) = (L - 1) \int_0^X p_X(x) dx$$

$$\begin{array}{ccc} Y = T(X) & & \\ \swarrow & & \searrow \\ p_Y(y) & & p_X(x) \end{array}$$

$T(X)$ is cts & differentiable

What is $p_Y(y)$?

$$p_Y(y) = p_X(T^{-1}(y)) \frac{d}{dy}(T^{-1}(y))$$

$$= \frac{1}{L-1} \cdot \frac{dT}{dx} \Big|_{x=T^{-1}(y)} \frac{d}{dy}(T^{-1}(y))$$

$$\frac{d}{dy}T(T^{-1}(y)) = \frac{d}{dy}y = 1$$

Histogram equalization

$$Y = T(X) = (L - 1) \int_0^X p_X(x) dx$$

$$\begin{array}{ccc} Y = T(X) & & \\ \swarrow & & \searrow \\ p_Y(y) & & p_X(x) \end{array}$$

$T(X)$ is cts & differentiable

What is $p_Y(y)$?

$$p_Y(y) = p_X(T^{-1}(y)) \frac{d}{dy}(T^{-1}(y))$$

$$= \frac{1}{L-1} \cdot \frac{dT}{dx} \Big|_{x=T^{-1}(y)} \frac{d}{dy}(T^{-1}(y))$$

$$\frac{d}{dy}T(T^{-1}(y)) = \frac{d}{dy}y = 1$$

$$= \frac{1}{L-1}$$

Histogram equalization

$$Y = T(X) = (L - 1) \int_0^x p_X(x) dx$$

$$\begin{array}{ccc} Y = T(X) & & \\ \swarrow & & \searrow \\ p_Y(y) & & p_X(x) \end{array}$$

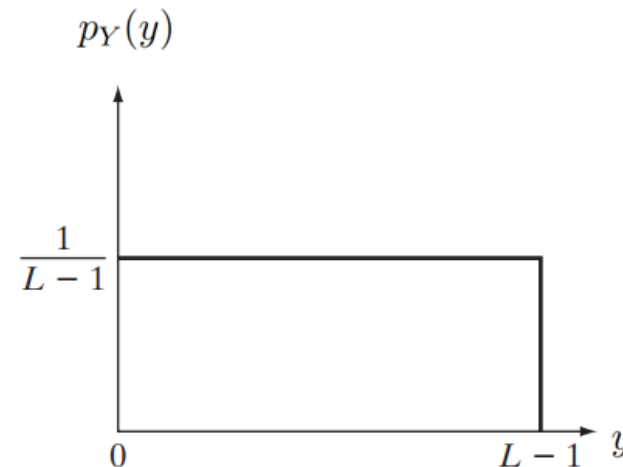
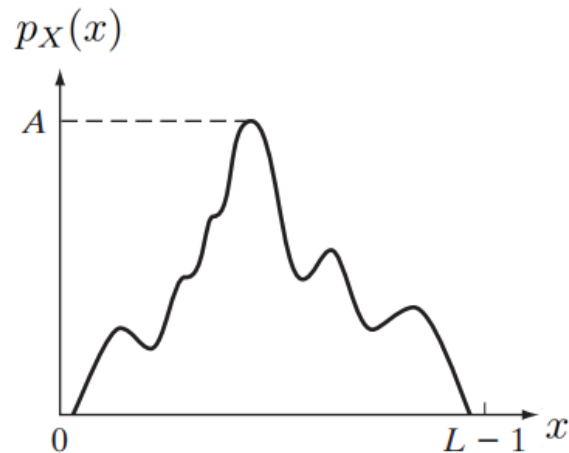
$T(X)$ is cts & differentiable

Histogram equalization

$$Y = T(X) = (L - 1) \int_0^X p_X(x) dx$$

$$\begin{array}{ccc} Y = T(X) & & \\ \swarrow & & \searrow \\ p_Y(y) & & p_X(x) \end{array}$$

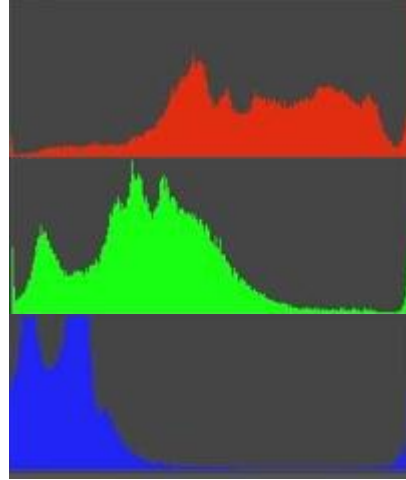
$T(X)$ is cts & differentiable



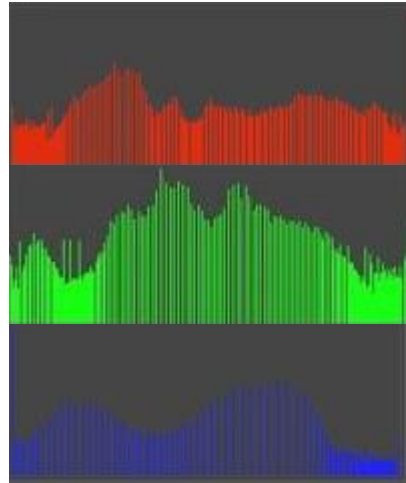
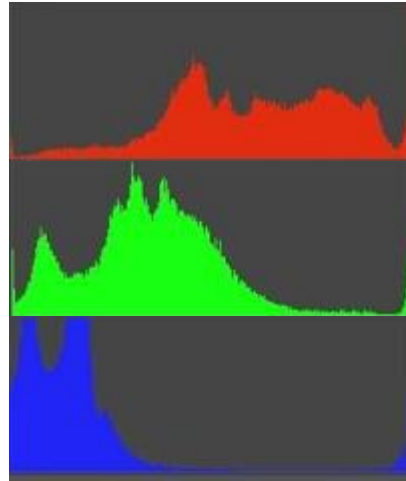
Histogram equalization



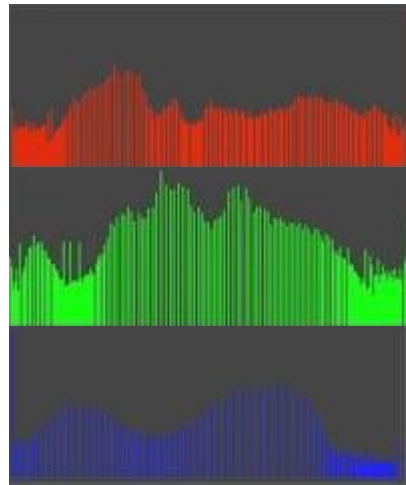
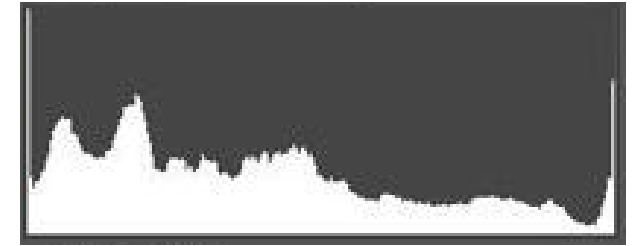
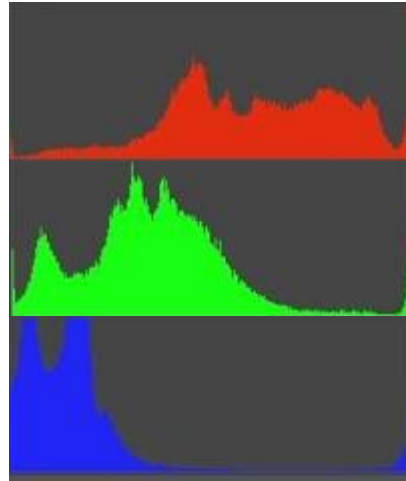
Histogram equalization



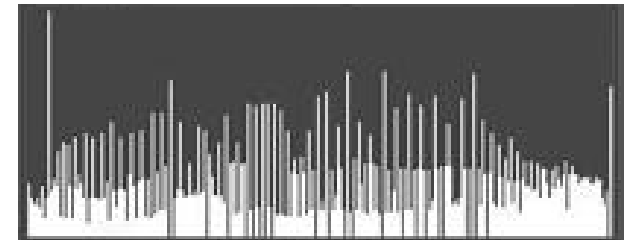
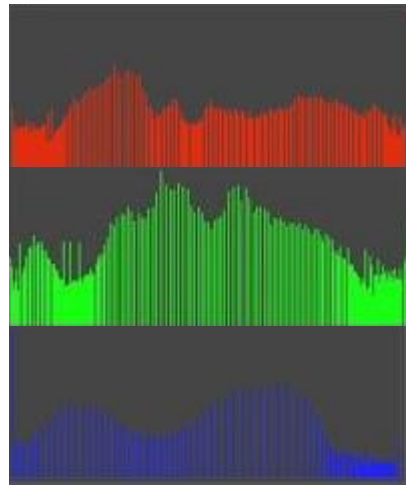
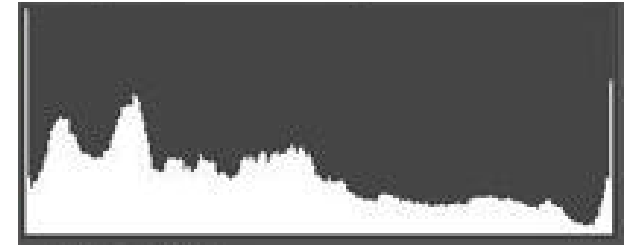
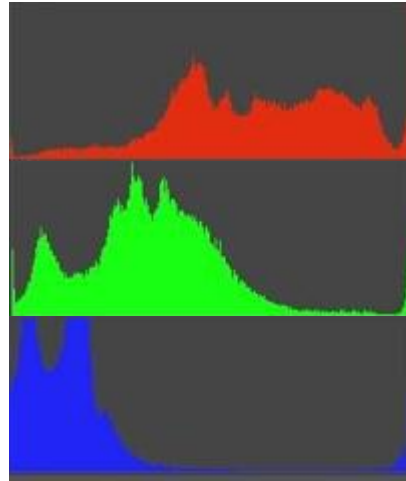
Histogram equalization



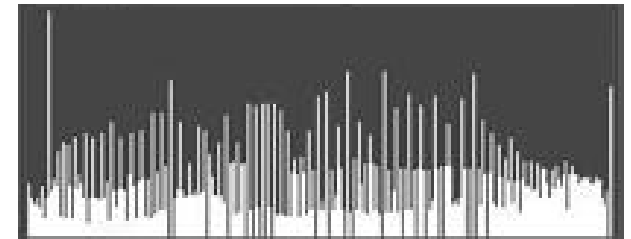
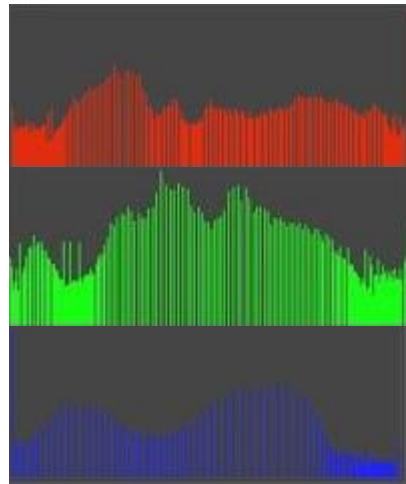
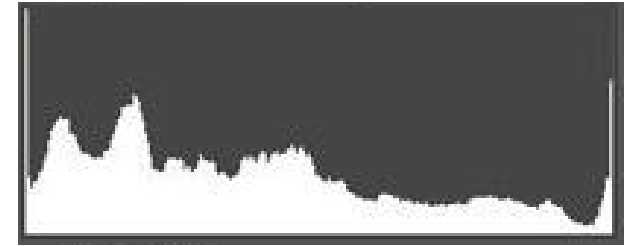
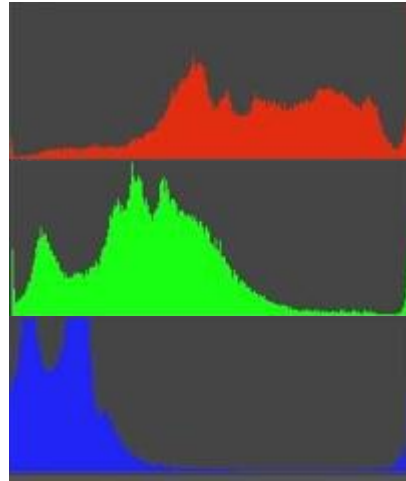
Histogram equalization







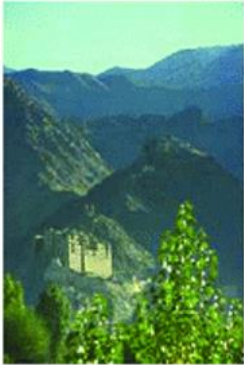
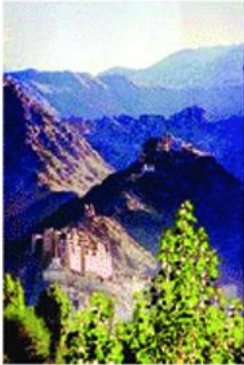
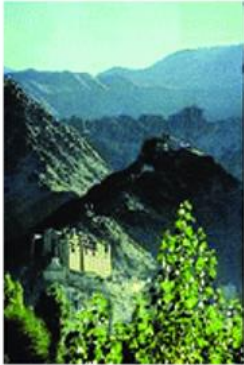
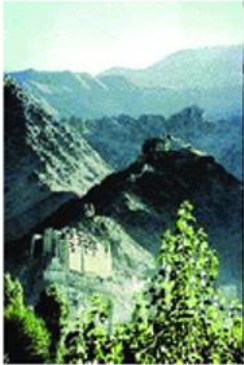
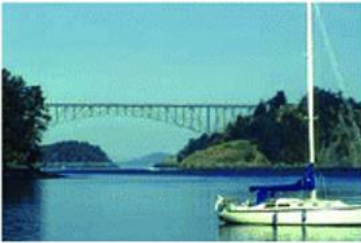
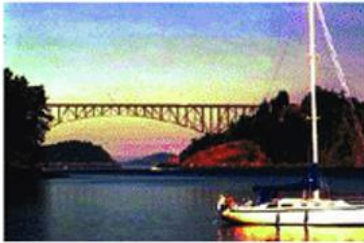
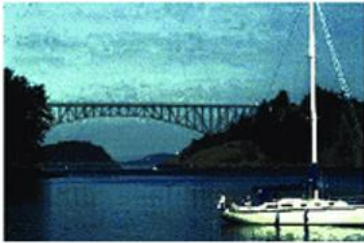





Histogram equalization



Histogram equalization





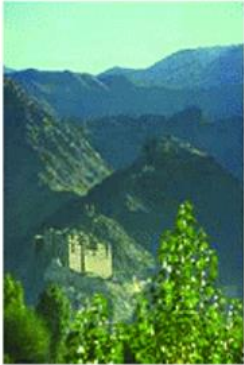

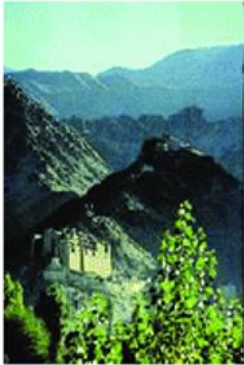
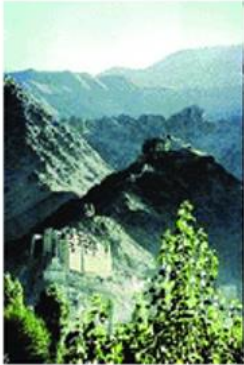
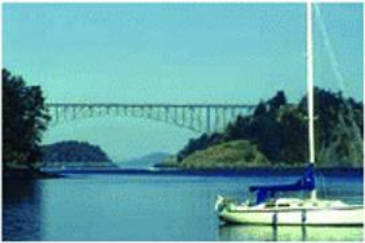
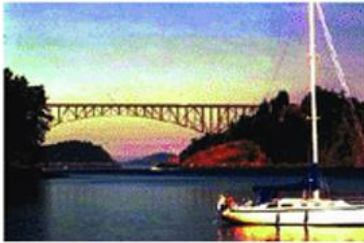

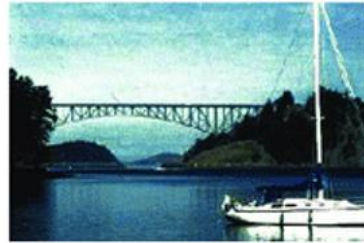






Histogram equalization

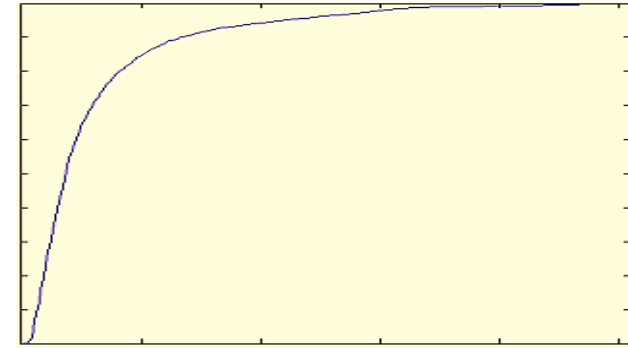
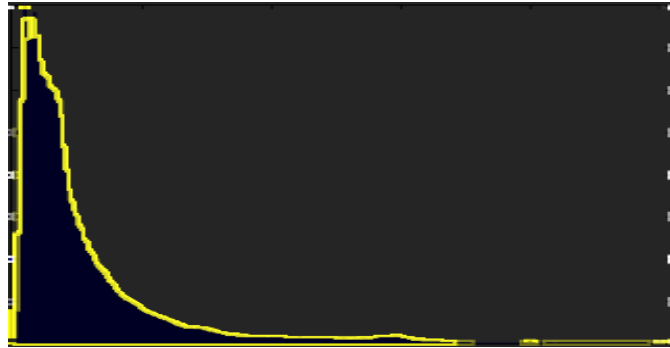
Original image	Color functions & Histogram equalization results		
	RGB	$f_1(\text{RGB})$	$f_2(\text{RGB})$
			
			
			
			

Histogram equalization

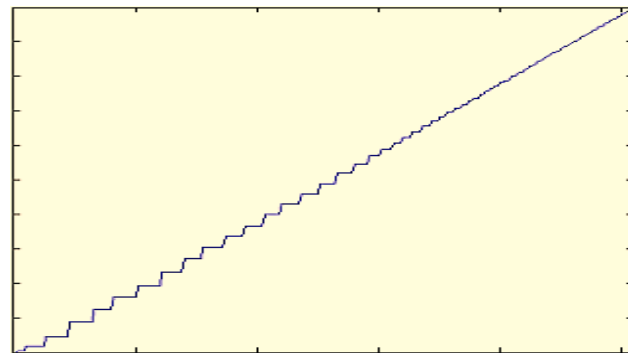
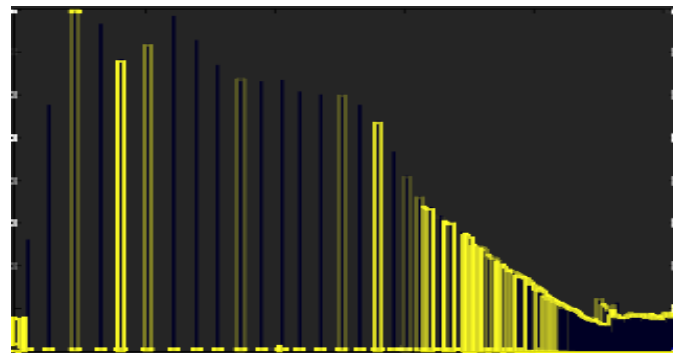
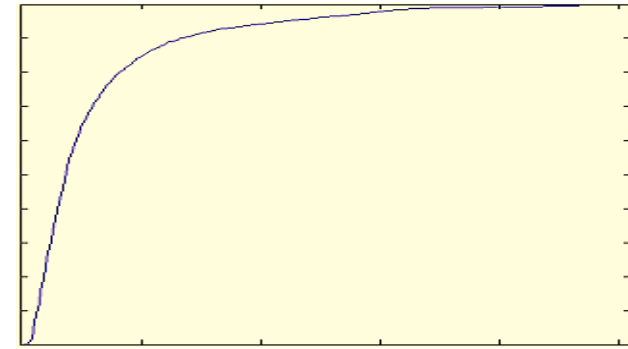
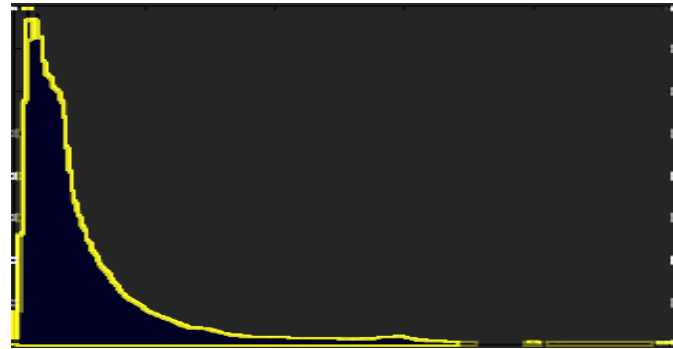
- Color conversions
 - colors can be mapped with certain functions
 - mapped images then histogram equalized

Original image	Color functions & Histogram equalization results		
	RGB	$f_1(\text{RGB})$	$f_2(\text{RGB})$
			
			
			
			

Histogram equalization



Histogram equalization

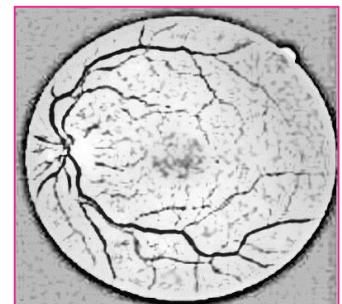


Conclusion

- Intensity transforms
- Distribution transforms

Conclusion

- Intensity transforms
- Distribution transforms



Conclusion

- Intensity transforms
- Distribution transforms

□ Intensity transformations

- negatives
- logs
- power-law (gamma)
- contrast stretching
- level slicing
- bit-plane slicing

□ Distribution transformations

- Histogram equalization

