Image Enhancement using Zero Memory Point Operations

Kiran TALELE

☎ **99 870 30 881**

Kiran TALELE

@ Bharatiya Vidya Bhavans' Sardar Patel Institute of Technology Andheri(w) Mumbai

- **Associate Professor,** Electronics Engineering Department (1997)
- **Dean,** Students, Alumni & External Relations (2022)

@ Sardar Patel Technology Business Incubator(SP-TBI), Funded by Department of Science & Technology(DST), Govt. of India

- **Head**, Academic Relations (2015)

@ IEEE Bombay Section

- **Treasurer** (2020)
- Executive Committee Member (2015)

Image Enhancement

Objective :

To process a given image so that the result is more suitable than the original image for a specific application.

- IMP : The enhancement process does not increase the inherent information content in the data.

  But it does increase the dynamic range of the chosen feature so that they con be detected easily.

[1] Image Enhancement using Zero Memory Point Operations

Let **r** denotes input image pixel value

and **s** denotes output image pixel value

Then $S = T(r)$

where **T** is any Spatial Domain Tx function.

Basic Gray Level Transformations using Zero Memory Point Operations

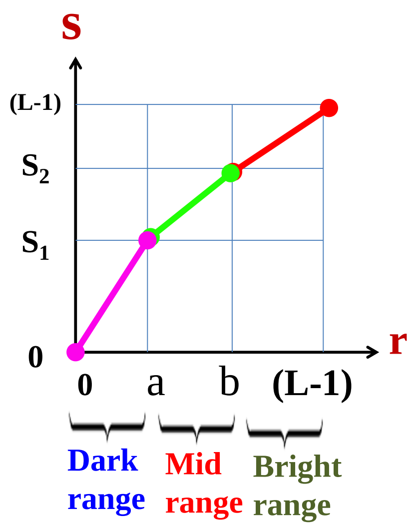
1. **Contrast Stretching Transformations**
2. **Clipping and Thresholding**
3. **Digital Negative**
4. **LOG Transformation**
5. **Power Law Transformation**
6. **Intensity Level Slicing**
7. **Bit Level slicing**

[1] Contrast Stretching Transformaton

(i) Low Contrast Image occur often due to

- Poor or Non-uniform Lighting conditions
- Limited dynamic range of imaging sensor
- Improper setting of lens aperature.

(ii) A Contrast Stretching Transformation function can be achieved by



- **Stretching** Dark range of input values into wider range of output values.
- **Shifting** Mid range of input values
- **Compressing** Bright range of input values.

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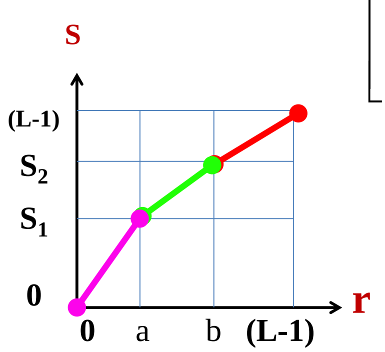
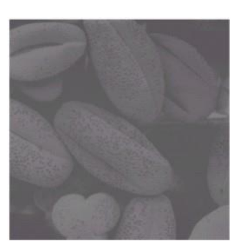
(iii) **Mathematically,**

It is defined as **S= T(r)**

where T is Contrast Stretching Tx function such that,

$$S = \begin{bmatrix} \alpha r & 0 \le r \le a \\ S_1 + \beta(r-a) & a < r \le b \\ S_2 + \gamma(r-b) & b < r \le L-1 \end{bmatrix}$$





Input Image

Output Image

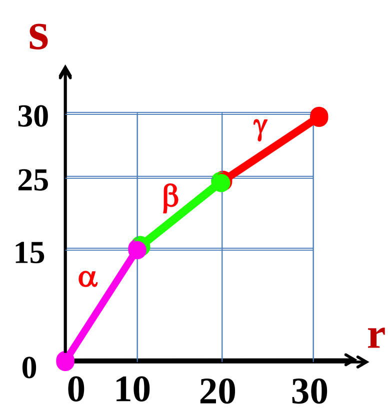
H.W. Derive Contrast Stretching Transformation Function.

Q1. Obtain the gray level transformation function that :

- **Stretches** gray scale range [0, 10] into [0, 15]
- **Shifts** the range [10,20] to [15,25] and
- **Compresses** the range [20,30] into [25,30].

ANS : Gray level transformation function that :

- **Stretches** gray scale range [0, 10] into [0, 15]
- **Shifts** the range [10,20] to [15,25] and
- **Compresses** the range [20,30] into [25,30].



$\alpha = 1.5$ $\beta = 1.0$ $\gamma = 0.5$

A Contrast Stretching Tx function is given by,

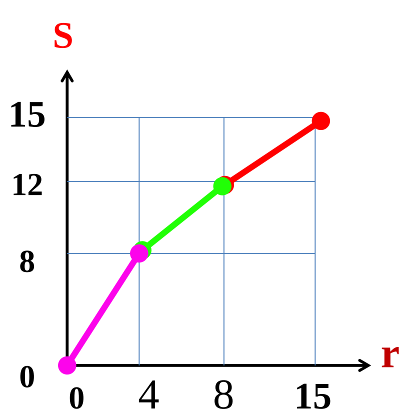
$$S = \begin{bmatrix} \alpha r & 0 \le r \le a \\ S_1 + \beta(r-a) & a < r \le b \\ S_2 + \gamma(r-b) & b < r \le L-1 \end{bmatrix}$$

Where **a = 10** **b = 20**
L-1 = 30
S1 = 15 **S2 = 25**
α = 1.5 **β = 1.0** **γ = 0.5**

By substituting we get,

$$S = \begin{bmatrix} \mathbf{1.5\ r} & 0 \le r \le a \\ \mathbf{S = r + 5} & a < r \le b \\ \mathbf{S = 10 + (0.5)\ (r\text{-}b\ )} & b < r \le L-1 \end{bmatrix}$$

Q2. Apply following Transformation function on the image F and obtain new image.



$$F = \begin{bmatrix} 7 & 12 & 2 & 3 & 4 \\ 10 & 15 & 1 & 6 & 7 \\ 12 & 4 & 6 & 15 & 12 \\ 8 & 2 & 7 & 15 & 2 \\ 11 & 13 & 3 & 3 & 5 \end{bmatrix}$$

[2] Clipping and Thresholding

(i) It is a special case of Contrast Stretching Tx function.

(ii) A Contrast Stretching Tx function is given by,

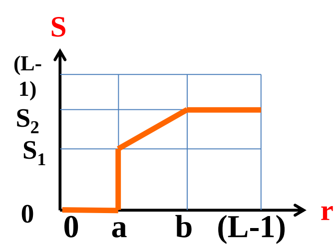
$$S = \begin{bmatrix} \alpha r & 0 \le r \le a \\ S_1 + \beta(r-a) & a < r \le b \\ S_2 + \gamma(r-b) & b < r \le L-1 \end{bmatrix}$$

Clipping . . .

$$S = \begin{bmatrix} \alpha r & 0 \le r \le a \\ S_1 + \beta(r-a) & a < r \le b \\ S_2 + \gamma(r-b) & b < r \le L-1 \end{bmatrix}$$

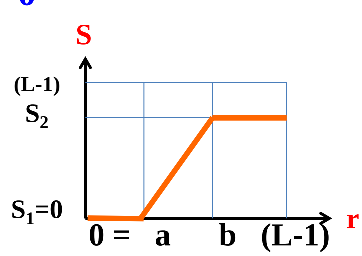
Case-1 : When $\alpha = 0$ and $\gamma = 0$

$$S = \begin{bmatrix} 0 & 0 \le r \le a \\ S_1 + \beta(r-a) & a < r \le b \\ S_2 & b < r \le L-1 \end{bmatrix}$$



Case-2 : When $\alpha = 0, \gamma = 0$ and $S_1 = 0$

$$S = \begin{bmatrix} 0 & 0 \le r \le a \\ \beta(r-a) & a < r \le b \\ S_2 & b < r \le L-1 \end{bmatrix}$$

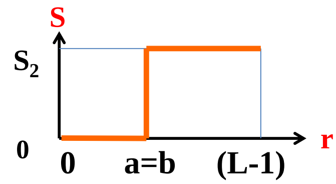


Thresholding . . .

$$S = \begin{bmatrix} \alpha r & 0 \le r \le a \\ S_1 + \beta(r-a) & a < r \le b \\ S_2 + \gamma(r-b) & b < r \le L-1 \end{bmatrix}$$

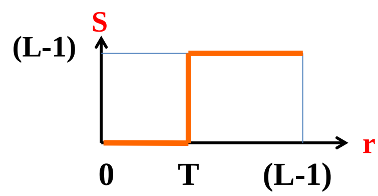
Case-3 : When $\alpha = 0, \gamma = 0$, $S_1 = 0$ and a == b

$$S = \begin{bmatrix} 0 & 0 \le r \le a \\ S_2 & b < r \le L-1 \end{bmatrix}$$



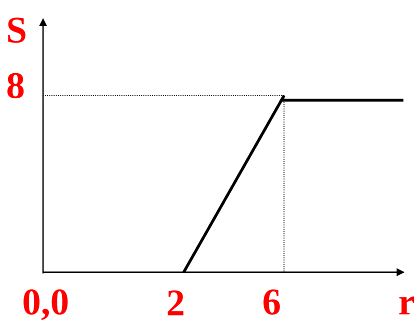
Thresholding Simplifies

$$S = \begin{bmatrix} (L-1) & \text{if } r > T \\ 0 & \text{Otherwise} \end{bmatrix}$$



Q4 Given Image F and Transformation Function.

(a) Obtain the new image.
(b) Plot Histogram of input & output Image
(c) Compare the histograms of I/O image.



F =

2	3	4	2
5	5	2	4
3	6	3	5
5	3	5	5

Q5. Given

$$F = \begin{bmatrix} 4 & 2 & 3 & 0 \\ 1 & 3 & 5 & 8 \\ 5 & 3 & 2 & 1 \\ 2 & 4 & 6 & 7 \end{bmatrix}$$

Threshold T = 4

Solution :

Max Pixel Value = 8

So, L = 2^4 **== 16**

By Thresholding Tx,

If r > (T = 4)
Then
S = 15 (Max = L-1)
Else
S = 0

Ouput Image :

A =

0	0	0	0
0	0	15	15
15	0	0	0
0	0	15	15

Q6 Convert the gray image to Binary Image. Select appropriate value of threshold from the histogram.

$$F = \begin{bmatrix} 0 & 3 & 0 & 1 & 0 \\ 1 & 7 & 4 & 5 & 2 \\ 2 & 6 & 6 & 7 & 7 \\ 7 & 4 & 0 & 1 & 0 \\ 5 & 6 & 7 & 6 & 5 \end{bmatrix}$$

[3] Digital Negative

Negative Image is obtained by reverse scaling of gray levels of input image.

(i) Mathematically

To find Slope

$\alpha =$ $= -1$

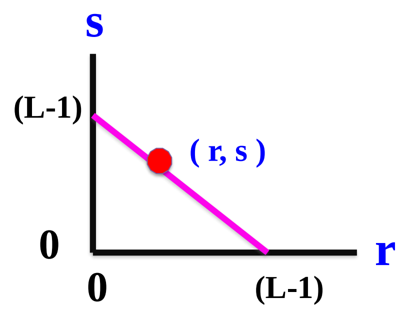
To find Slope

$\alpha =$ $= -1$

$S = \alpha[\, r - (L-1) \,]$

$$\boxed{S = (L-1) - r}$$

(ii) Graphically



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Application :

[1] To obtain negative prints of Photograph

[2] To display Medical Images

Q7. Given Image

$$F = \begin{bmatrix} 4 & 2 & 3 & 0 \\ 1 & 3 & 5 & 8 \\ 5 & 3 & 2 & 1 \\ 2 & 4 & 6 & 7 \end{bmatrix}$$

Obtain Negative

To find Output Image A:

By Digital Nagative Tx,

$S = (L-1) - r$

Where L = 2^4 == 16

$\boxed{S = 15 - r}$

Ouput Image :

A =

11	13	12	15
14	12	10	7
10	12	13	14
13	11	9	8

[4] LOG Transformation

(i) Mathematically,

$S = C \, \text{Log} (1 + r)$

Where,

r is input image pixel value

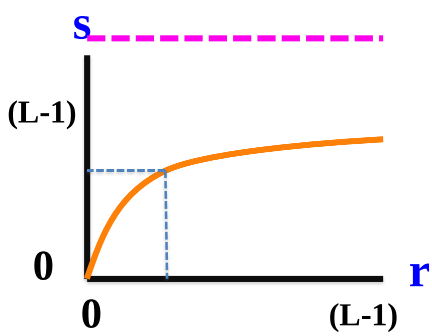
S is output image pixel value

And C is any Constant

Application :

To display Fourier Transformed Image

(ii) Graphically,



(i) LOG Tx,
Enhances small magnitude input values into wider range of output values

(ii) **LOG Tx,**
Compresses large magnitude input values into narrow range of output values

Q8. Given Image F, Obtain the new image using LOG Transformation.

F =

128	212	25
54	0	124
4	152	15

[5] Power Law Transformation

Mathematically,

$s = r^{\gamma}$

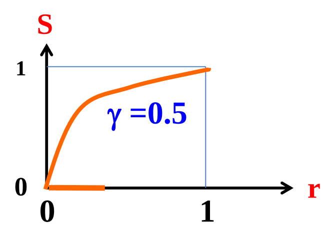
Where,

r is Normalized input image pixel value

S is Normalized output image pixel value

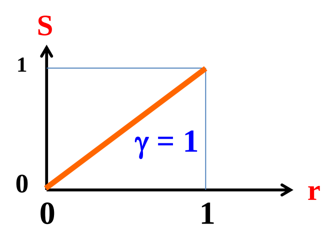
(i) When $\gamma < 1$

PLT maps narrow range of dark input values into wider range of ouput values



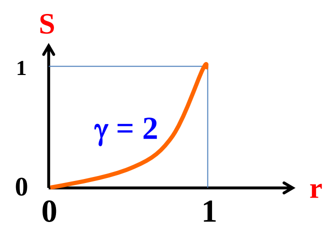
(ii) When $\gamma = 1$

Output Pixel Value = Input Pixel Value



(iii) When $\gamma > 1$

PLT maps wider range of input values into narrow range of ouput dark pixel values



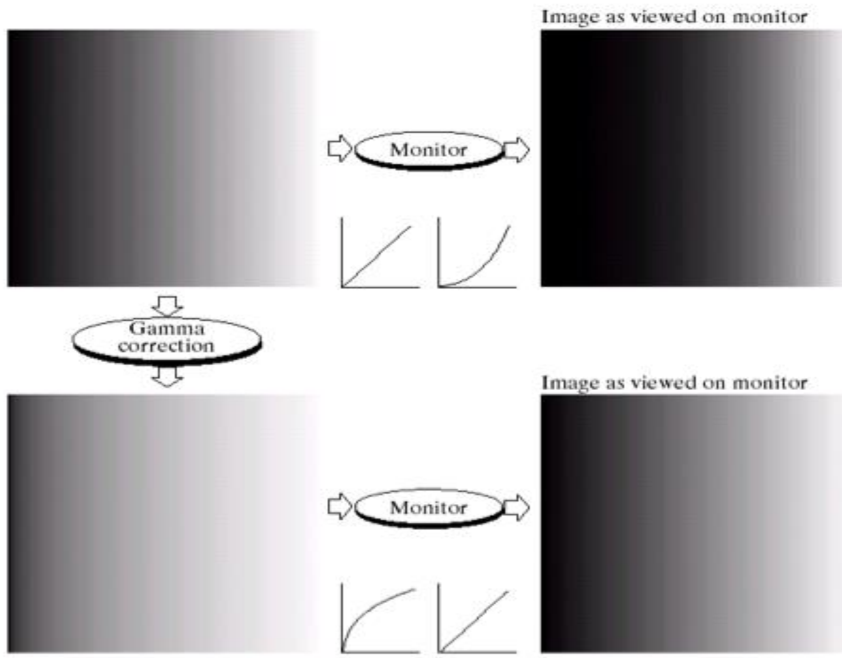
Q9. For the image given below perform the operation $S = r^2$

A =

0	2	4	0
6	6	0	4
2	8	2	8
6	2	6	8

Application : Gamma Correction

- A cathode ray tube (CRT), converts a video signal to light in a nonlinear way. The light intensity is proportional to a power (γ) of the source voltage
- For a computer CRT, γ is about 2.2
- Viewing images properly on monitors requires γ-correction

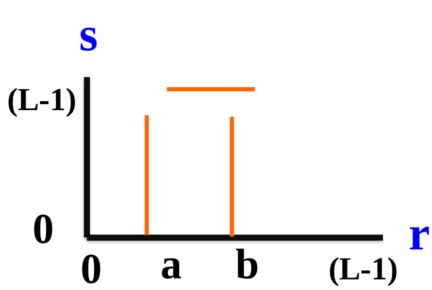


[6] Intensity Level Slicing

Highlighting a specific range of input values is called Intensity Level Slicing

Case-1 : Without Background

(i) Graphically

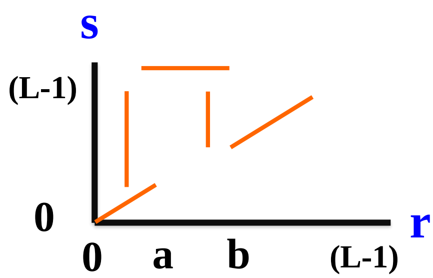


(Ii) Mathematically

$$S = L-1 \quad \text{if} \quad a < r < b$$
$$\quad = 0 \quad \text{Otherwise}$$

Case-2 : With Background

(i) Graphically



(ii) Mathematically

$$S = L-1 \quad \text{if} \quad a < r < b$$
$$= r \quad \text{Otherwise}$$

Q10. For the image given below perform the Intensity Level Slicing for a = 2 and b = 5 with background and without background

A =

4	2	3	0
1	3	5	7
5	3	2	1
2	4	6	7

[7] Bit Level Slicing

Highlighting a specific **bit** of input pixel values is called Bit Level Slicing.

Mathematically :

For r = [bn,…b2, b1, b0]

If (bn = 1)
Then S = L-1
Otherwise S = 0

Ex. Consider 3 bit image with r = [b2, b1, b0] and L-1 = 7

A =

0	2	4
3	6	3
5	7	1

=

000	010	100
011	110	011
101	111	001

To highlight MSB bit of every pixel :

For r = [b2, b1, b0]

If (b2 = 1)
Then S = 7
Otherwise S = 0

B =

0	0	7
0	7	0
7	7	0

Dr. Kiran TALELE

- Academic : PhD
- Professional :
  - Dean-Students, Alumni & External Relations @ Bharatiya Vidya Bhavans' Sardar Patel Institute of Technology (SP-IT), Mumbai
  - Head-Academic Relation @ Sardar Patel Technology Business Incubator (SP-TBI), Mumbai
  - Treasurer-IEEE Bombay Section

091-9987030881
kiran.talele@spit.ac.in / ktvtalele@gmail.com
https://www.linkedin.com/in/k-t-v-talele/
www.facebook.com/Kiran-Talele-1711929555720263

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- **Dr. Kiran TALELE** is an Associate Professor in Electronics & Telecommunication Engineering Department of Bharatiya Vidya Bhavans' Sardar Patel Institute of Technology, Mumbai with 33+ years experience in Academics.
- He is a Dean of Students, Alumni and External Relations at Sardar Patel Institute of Technology, Andheri Mumbai.
  He is also a Head of Sardar Patel Technology Business Incubator, Mumbai.
- His area of research is Digital Signal & Image Processing, Computer Vision, Machine Learning and Multimedia System Design.
- **He has published 85+ research papers at various national & international refereed conferences and journals. He has filed published 12+ patents at Indian Patent Office. One patent is granted in 2021.**
- He is a Treasurer of IEEE Bombay Section and Mentor for Startup Incubation & Intellectual Asset Creation.
- He received incentives for excellent performance in academics and research from Management of S.P.I.T. in 2008-09. He is a recipient of P.R. Bapat IEEE Bombay Section Outstanding Volunteer Award 2019.


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