CMP362/CMPN446: Image Processing and Computer Vision

Lecture 03: Image Preprocessing

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Agenda

- Introduction
- Pixel Brightness Transformation
  - Grey Scale Transformation
    - Negative Transformation
    - Brightness Thresholding
    - Gamma Correction
    - Contrast Enhancement
  - Histogram Processing

Introduction

- Pre-processing techniques are operations on images at the lowest level of abstraction.
- These techniques are **used to suppress undesired distortions** or **enhance some image important features.**

Pixel Brightness Transformation

- Brightness transformation depends on the **pixel only.**
  - Grey scale Transformation
  - Histogram Processing

Grey Scale Transformation

- Brightness transform **from an intensity p to intensity q** independent of the position

$$q = T(p)$$

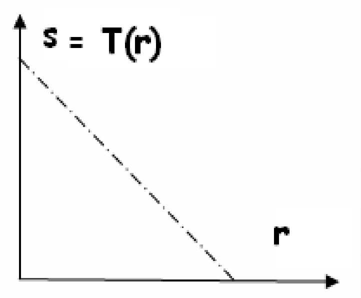
- Can be performed using a look up table
- Mostly used if the result is viewed by a human

Grey Scale Transformation Methods

- Negative Transformation
- Brightness Thresholding
- Gamma Correction
- Contrast Enhancement

Grey Scale Transformation Methods

- **Negative Transformation**

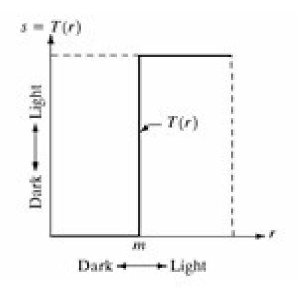


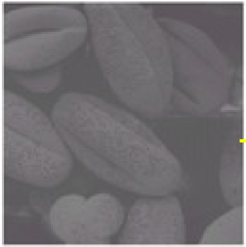
s = 255 - r

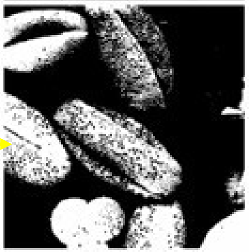
s = (L – 1) – r (General form)

Grey Scale Transformation Methods

- **Brightness Thresholding**





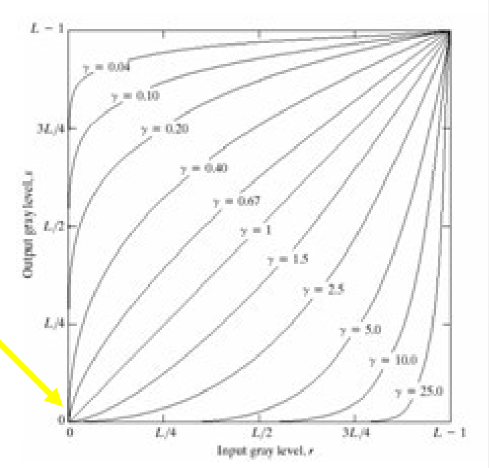


Grey Scale Transformation Methods

- **Gamma Correction**

$$V_{out} = cV_{in}^{\gamma}$$

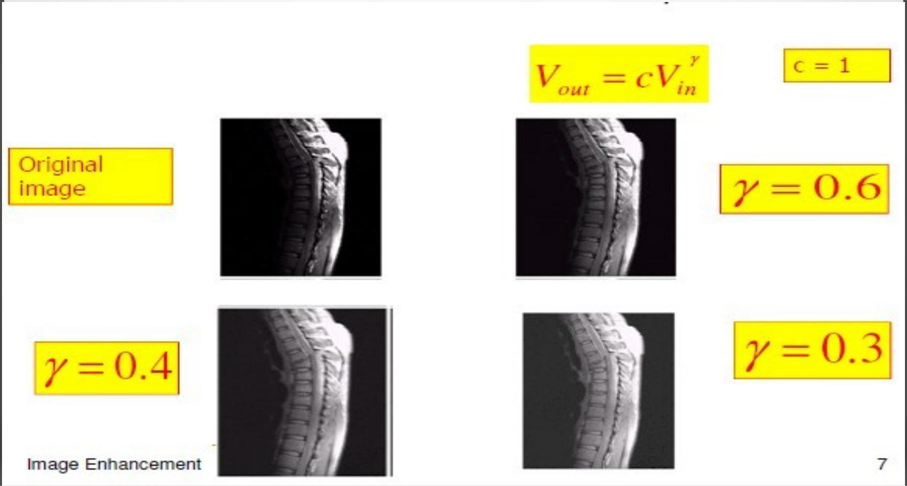
Increasing gamma



This type of transformation is used for enhancing images for
different type of display devices. The gamma of different display
devices is different. For example Gamma of CRT lies in between of
1.8 to 2.5, that means the image displayed on CRT is dark.

Grey Scale Transformation Methods

- **Gamma Correction**



Grey Scale Transformation Methods

- **Gamma Correction**

$$V_{out} = cV_{in}^{\gamma}$$

c = 1

Original image

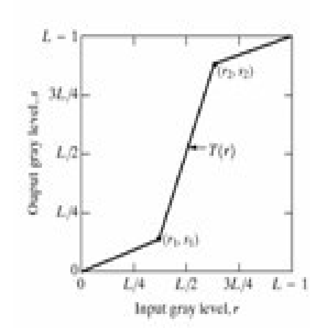
$\gamma = 3$

$\gamma = 4$

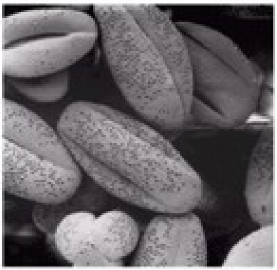
$\gamma = 5$

Grey Scale Transformation Methods

- **Contrast Enhancement**
  - **Contrast Stretching Using Linear Transform**



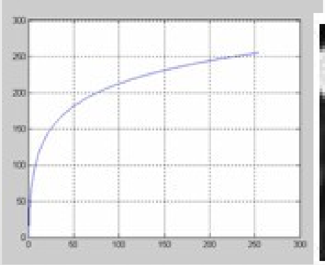
original image



after processing

Grey Scale Transformation Methods

- **Contrast Enhancement**
  - **Contrast Stretching Using Log Transform**



$$T(r) = c\log(1+r)$$

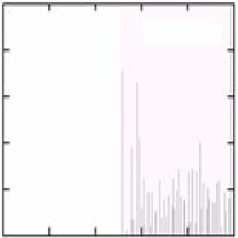
original image

after processing

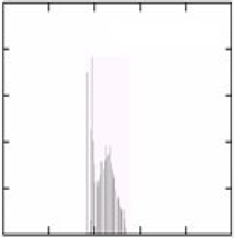
The value 1 is added to each of the pixel value of the input image
because if there is a pixel intensity of 0 in the image, then log (0)
is equal to infinity. So 1 is added, to make the minimum value at
least 1.
During log transformation, the dark pixels in an image are
expanded as compare to the higher pixel values. The higher pixel
values are kind of compressed in log transformation. This result in
following image enhancement.
The value of c in the log transform adjust the kind of
enhancement you are looking for.

Histogram Processing

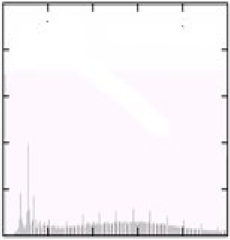
Bright Image



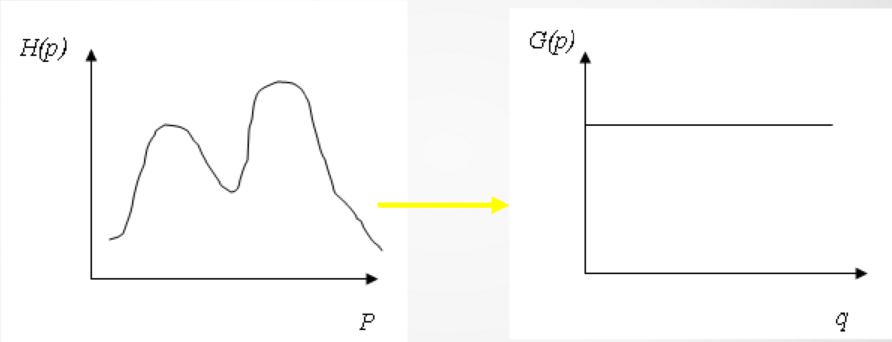
Low Contrast Image



High Contrast Image



Histogram Equalization



$$p(r) = \left(\frac{\text{Number of pixels with intensity } r}{\text{Total number of pixels}} \right)$$

Histogram Equalization

Steps: Histogram Equalization Algorithm

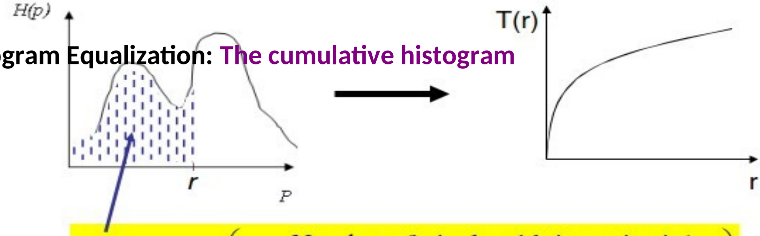
1. For an N x M image with G gray-levels, create an array H with a length G initialized with zeros.
2. Calculate the histogram of gray-levels for the image.
3. Form the cumulative image histogram, H_c. The cumulative histogram tells you how many pixels have gray-levels less than or equal to the p-th gray-level. The calculation is:

   H_c[0]=H[0] then: H_c[p]=H_c[p-1]+H[p]
4. Set the mapping between gray-levels as:

   q = T[p] = round((G-1) H_c[p] /(N M))
5. Go through the image, pixel-by-pixel and write an output image with gray-levels g_q using the mapping from step 4.

Histogram Equalization

Histogram Equalization: The cumulative histogram



$$T(r) = round\left(255 \frac{\text{Number of pixels with intensity } i \le r}{\text{Total number of pixels}}\right)$$

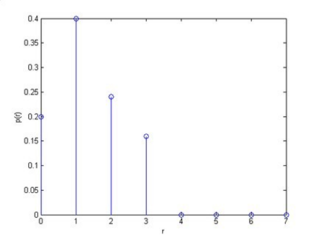
$$= round\left(255 \sum_{i=0}^{r} \frac{\text{Number of pixels with intensity } i}{\text{Total number of pixels}}\right)$$

$$= round\left(255 \sum_{i=0}^{r} p(i)\right)$$

$$0 \le r \le 255$$

Histogram Equalization Example

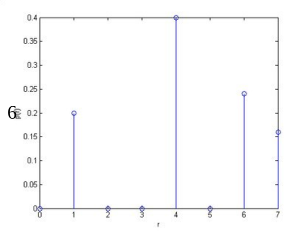
Intensity	0	1	2	3	4	5	6	7
Number of pixels	10	20	12	8	0	0	0	0



$$p(0) = 10/50 = 0.2$$
$$p(1) = 20/50 = 0.4$$
$$p(2) = 12/50 = 0.24$$
$$p(3) = 8/50 = 0.16$$
$$p(r) = 0/50 = 0, \quad r = 4, 5, 6, 7$$

$$T(r) = round\left(7\sum_{i=0}^{r} p(i)\right)$$

$$T(0) = round\left(7 * p(0)\right) = round\left(7 * 0.2\right) = 1$$
$$T(1) = round\left(7 * \left(p(0) + p(1)\right)\right) = round\left(7 * 0.6\right) = 4$$
$$T(2) = round\left(7 * \left(p(0) + p(1) + p(2)\right)\right) = round\left(7 * 0.84\right) = 6$$
$$T(3) = round\left(7 * \left(p(0) + p(1) + p(2) + p(3)\right)\right) = 7$$
$$T(r) = 7, \quad r = 4, 5, 6, 7$$



Intensity	0	1	2	3	4	5	6	7
Number of pixels	0	10	0	0	20	0	12	8

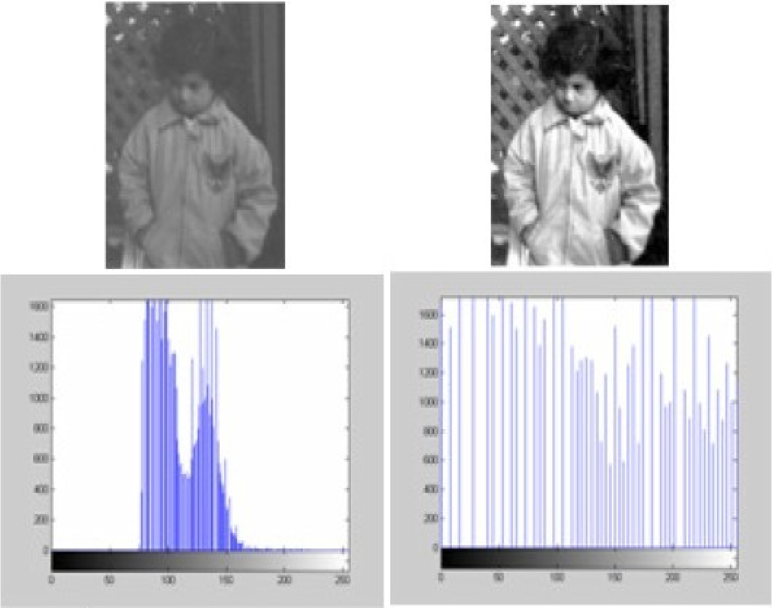
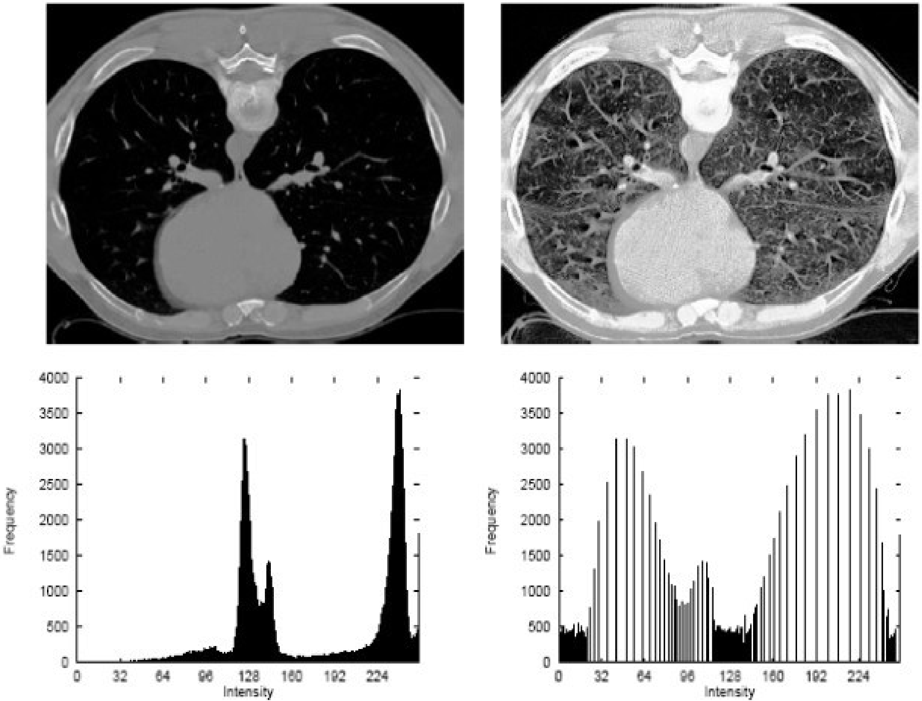


Image Enhancement



4000
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3000
2500
2000
1500
1000
500
0
Frequency
0
32
64
96
128
160
192
224
Intensity
4000
3500
3000
2500
2000
1500
1000
500
0
Frequency
0
32
64
96
128
160
192
224
Intensity