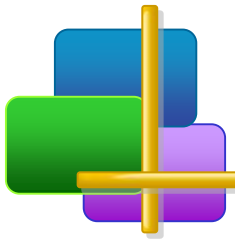
(I'm Fun) Digital Image Fundamentals



Week 3: Histogram Equalization

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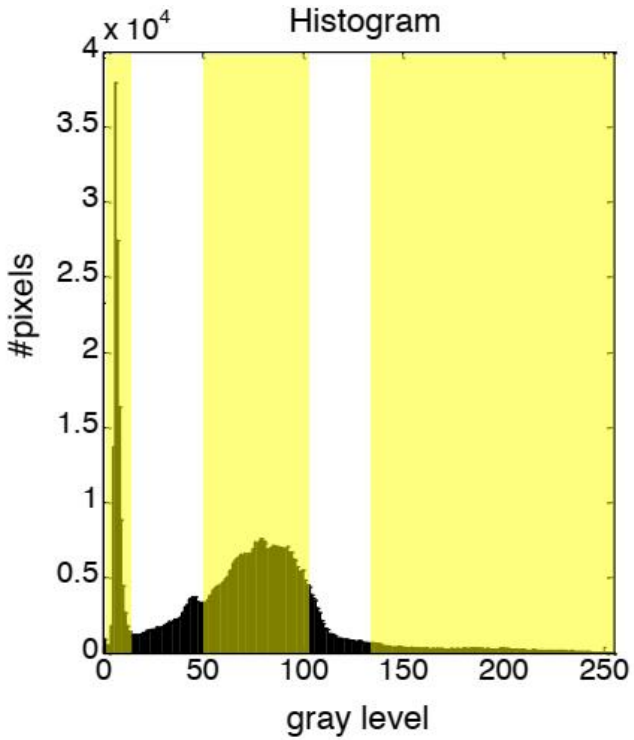
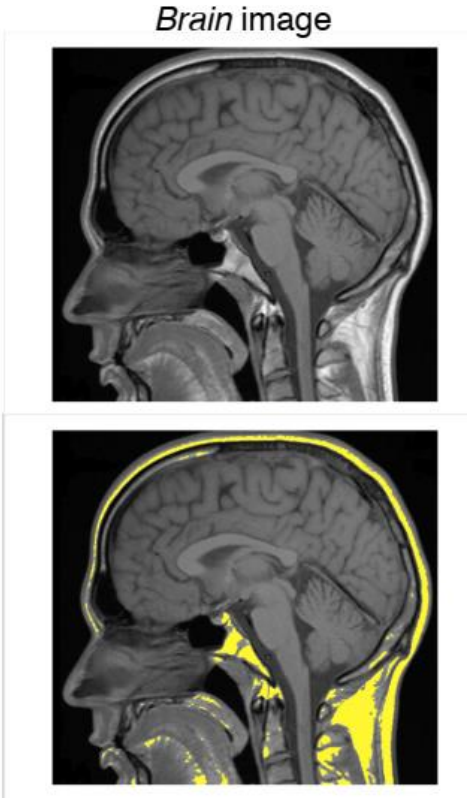
This material is based on the Digital Image Processing, Stanford University, Prof. Bernd Girod.

Histogram (1)

- The histogram of an image is the density probability distribution of the pixel val ues in the image over the entire gray scale range.
  - For 8-bit image, 256 discrete gray level from 0 to 255, normalized histogram is



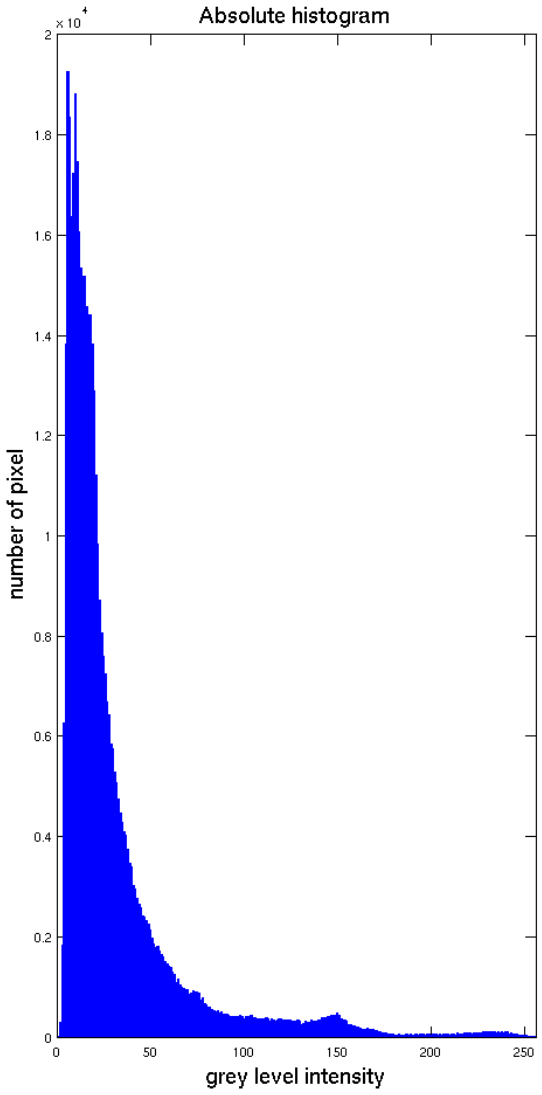


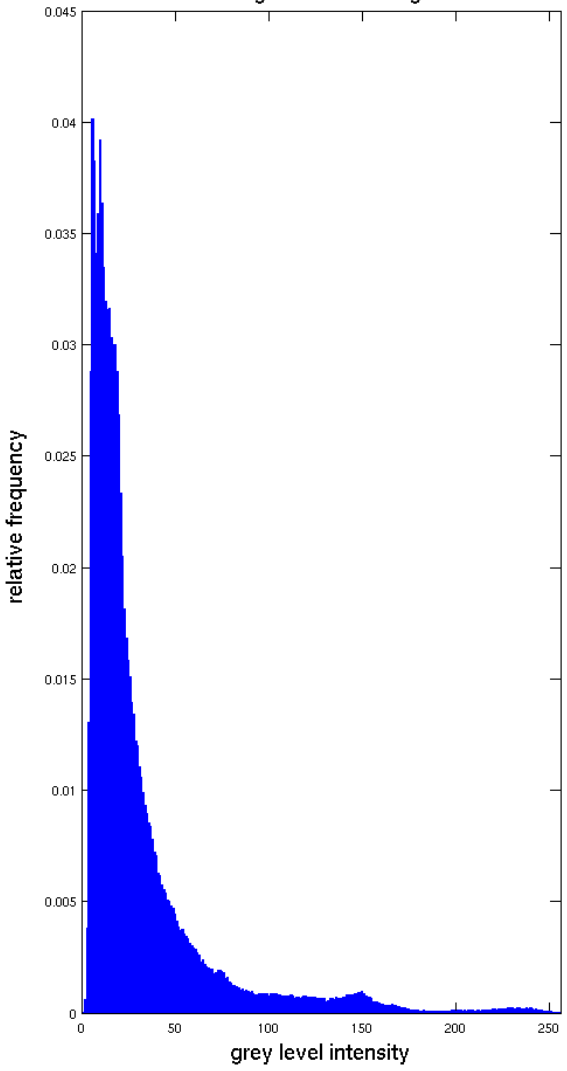
$$h[i] = \frac{n_i}{M \times N},$$
$$(i = 0, \ldots, L-1 = 255)$$

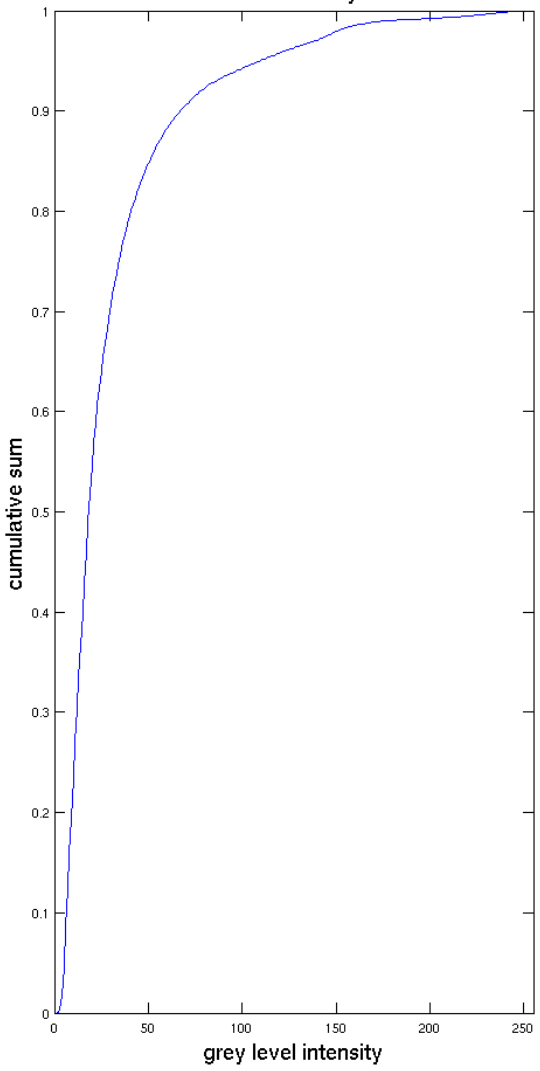
- n_i number of pixels of gray level i
- Image size $M \times N$

http://fourier.eng.hmc.edu/e161/lectures/contrast_transform/node1.html
http://www.sci.utah.edu/~acoste/uou/Image/project1/Arthur_COSTE_Project_1_report.html#histogram

Histogram (2)


Absolute histogram
x 10^4
number of pixel
grey level intensity


histogram of the image
relative frequency
grey level intensity


Cumulative Probability Function
cumulative sum
grey level intensity

Histogram (3)

Simple implementation (Binsize = 1)

```
For each pixel of the image
    value = Intensity(pixel)
    histogram(value)++
end
```

$$binsize = \left\lceil \frac{\max - \min}{n} \right\rceil$$

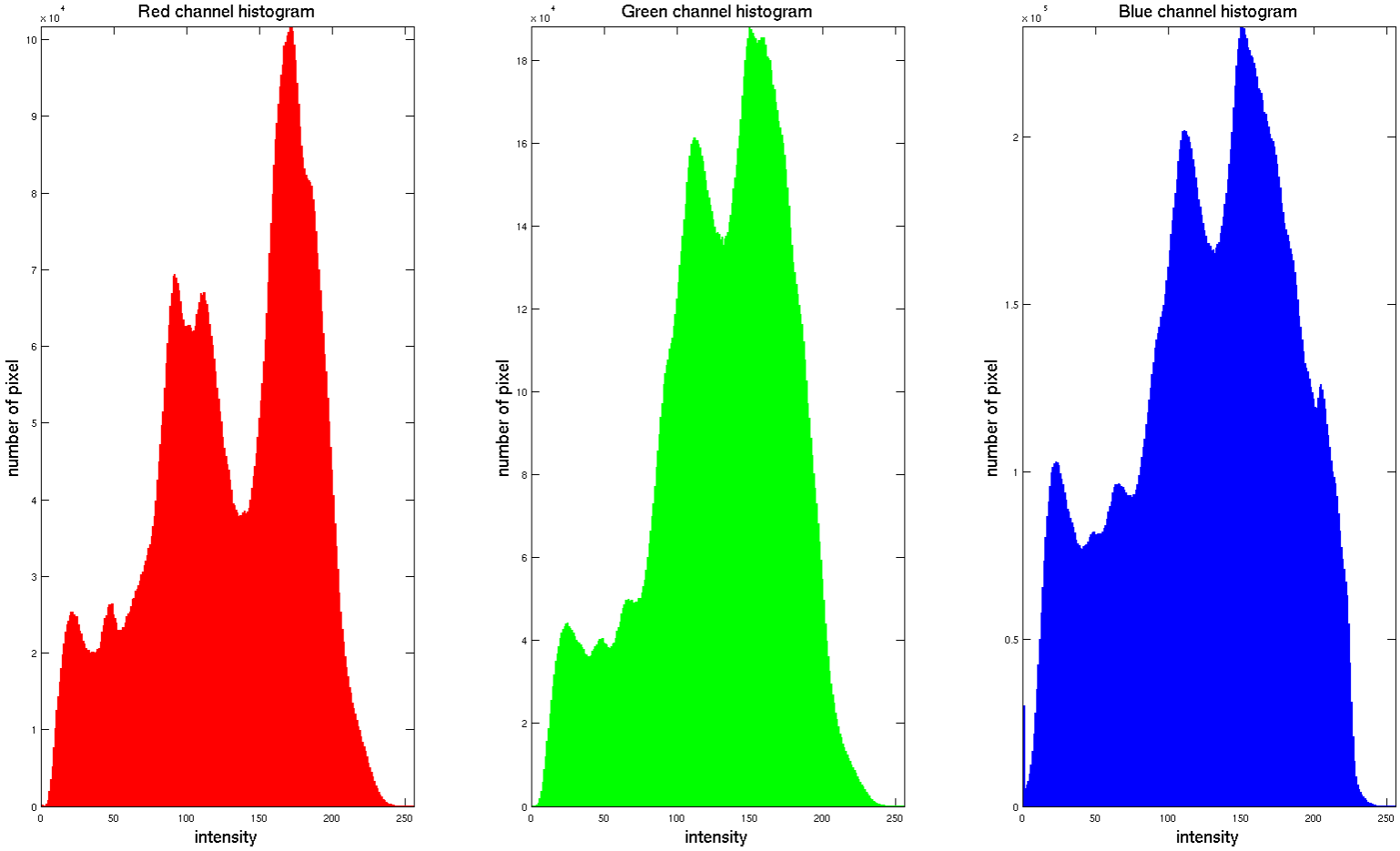
Implementation with bin information

```
define bin width
For each value read from the image
    value belong to [min,max] interval ?
      if yes find in which bin and increment bin
      else return
      end
end
```

```
% Load test image
img = imread('bay.jpg');
[counts, index] = imhist(img);
```

Histogram (4)

- Histogram of image channels are difference



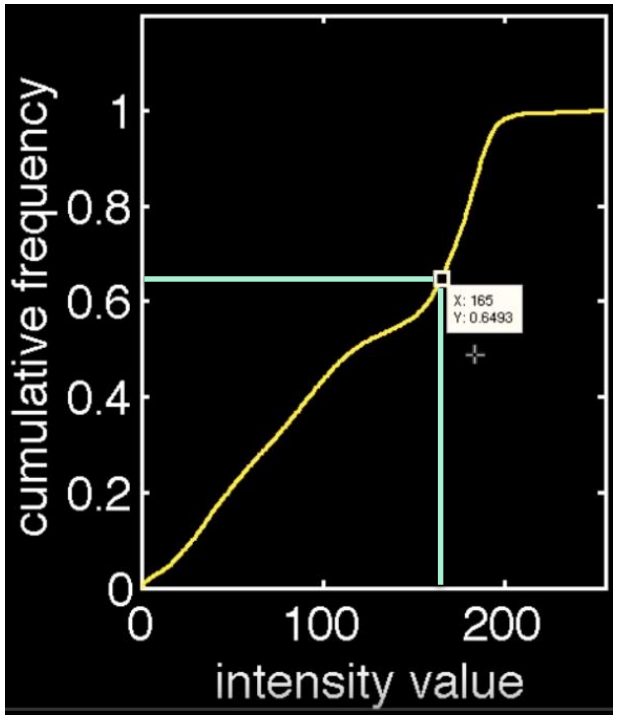
Histogram Equalization

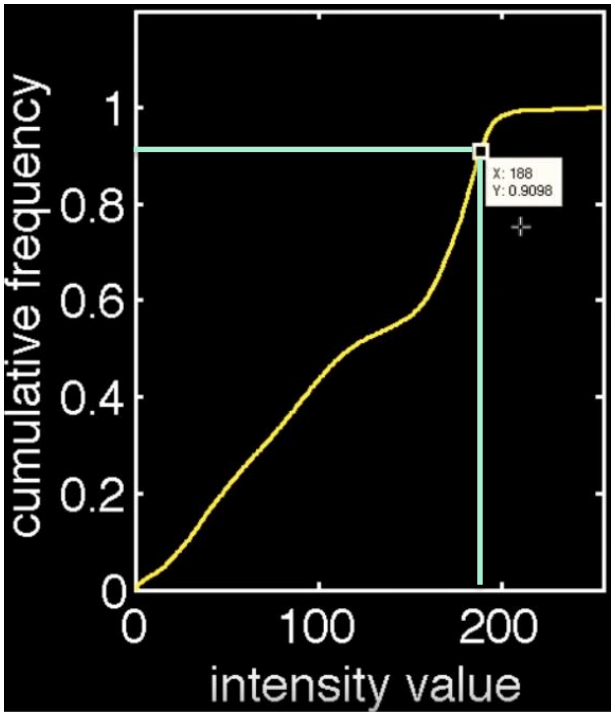
- A way to distribute the image histogram uniformly within the image
  - Find a non-linear transformation for each pixel

```
% Perform histogram equalization
eqImg = histeq(img);
```

$$g = T(f)$$

- Using the Cumulative Frequency Distribution as a “transform information”

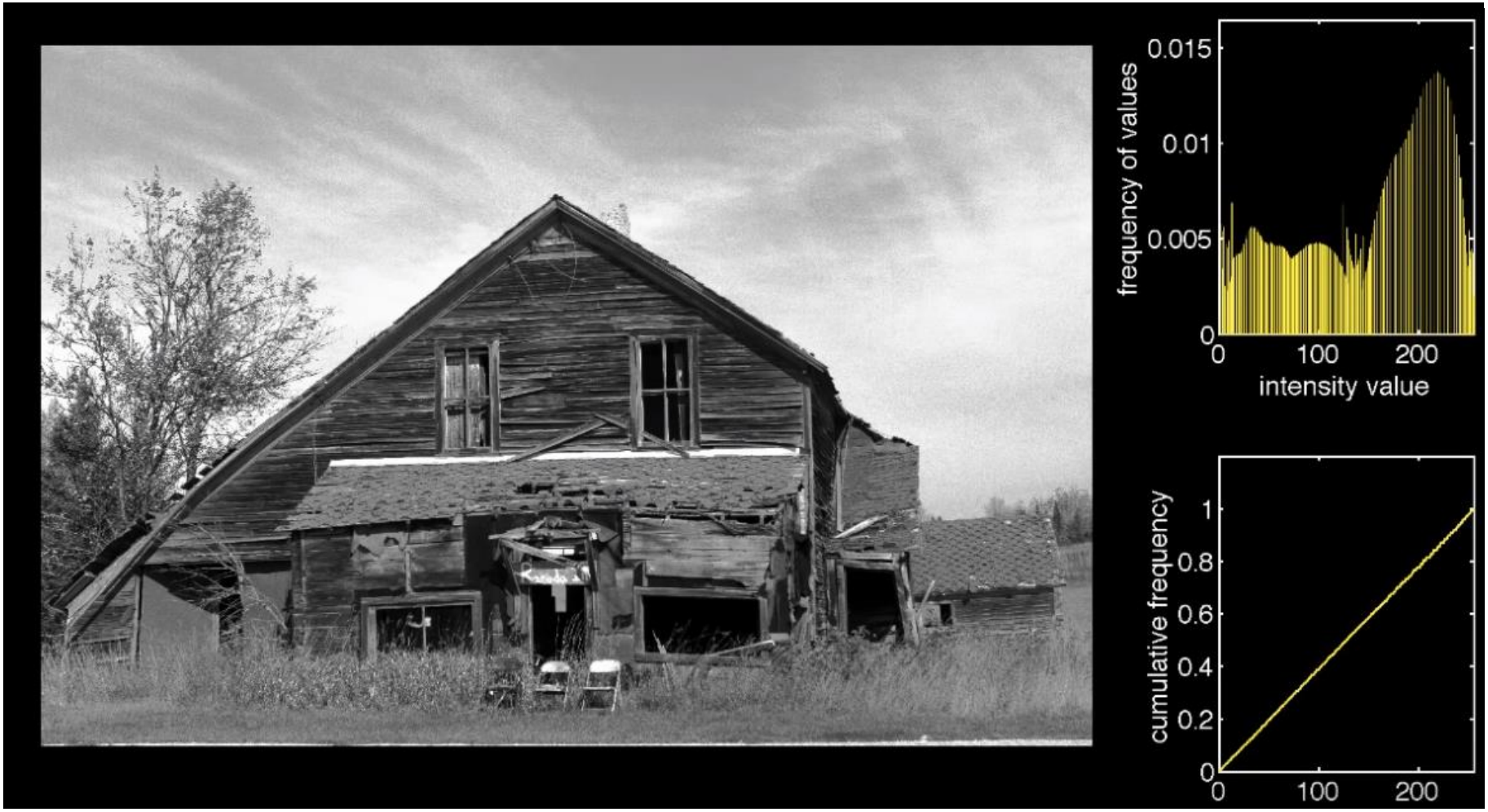




Mapping the image intensity

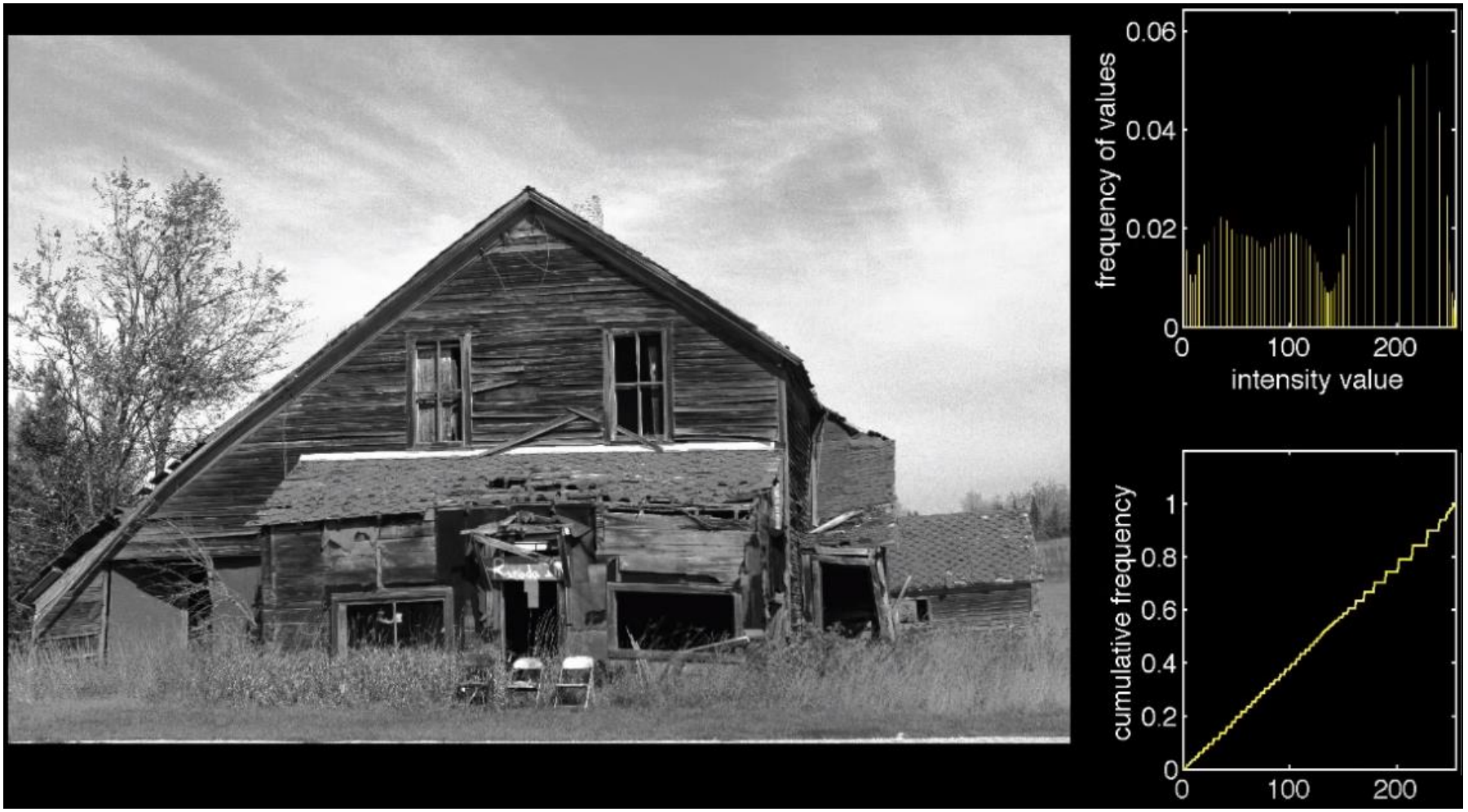
Why Histogram Equalization?

Enhance the quality of images (poor contrast images)



Example (1)

Under exposed images (dark images)

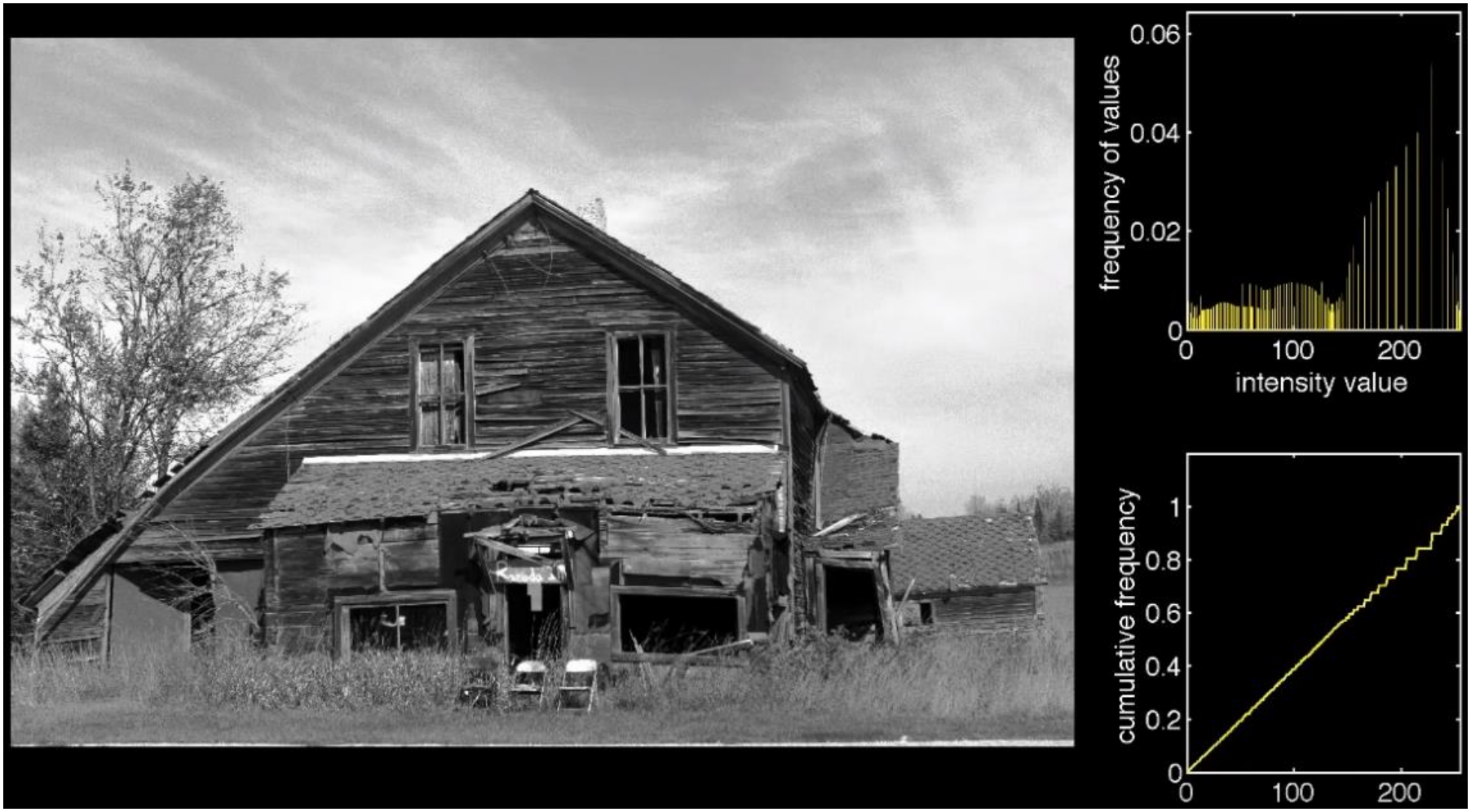


Pixel value is equally distributed

https://www.youtube.com/watch?v=WuVyG4pg9xQ

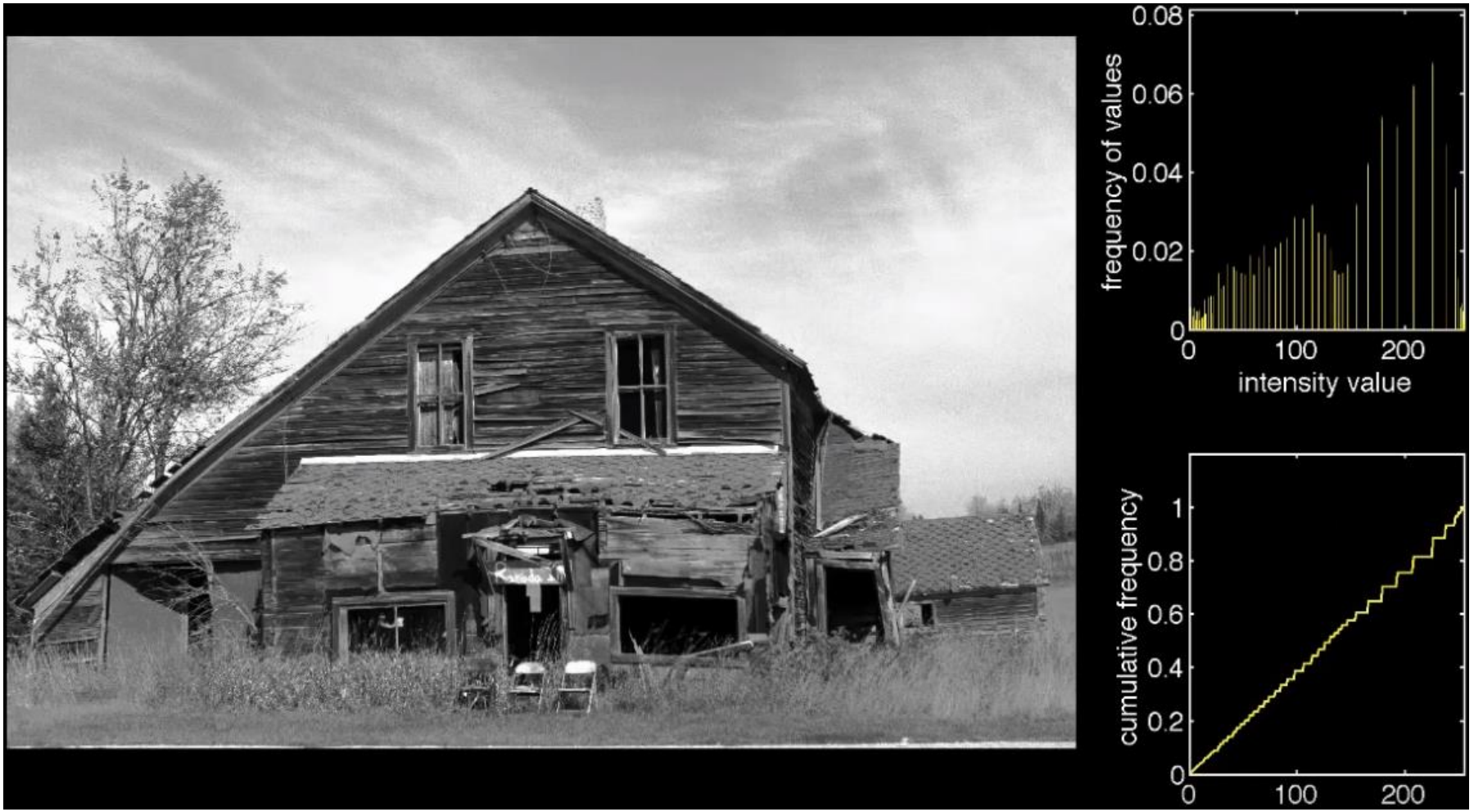
Example (2)

Over exposed images



Example (3)

Low Contrast Image



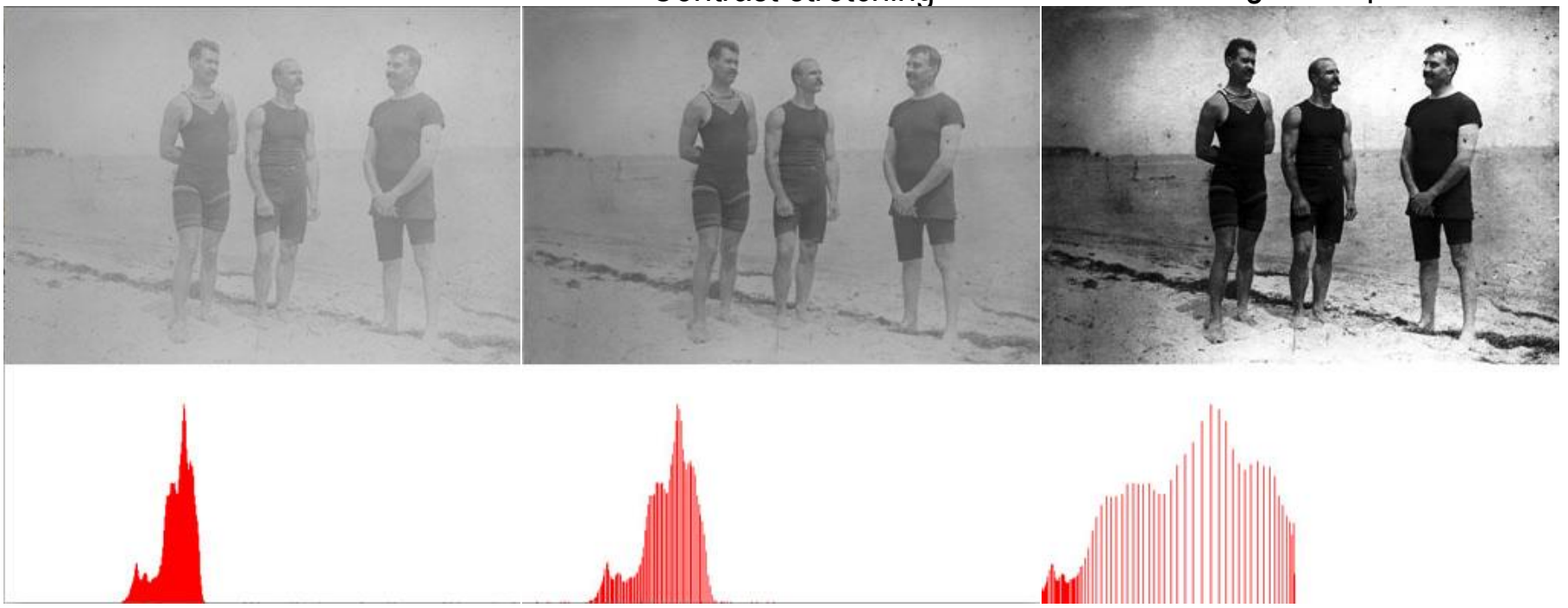
Example (4)

High Contrast Image

Why Histogram Equalization?

Contrast stretching

Histogram Equalization



Stretch the range to span from 0 to 255 ?

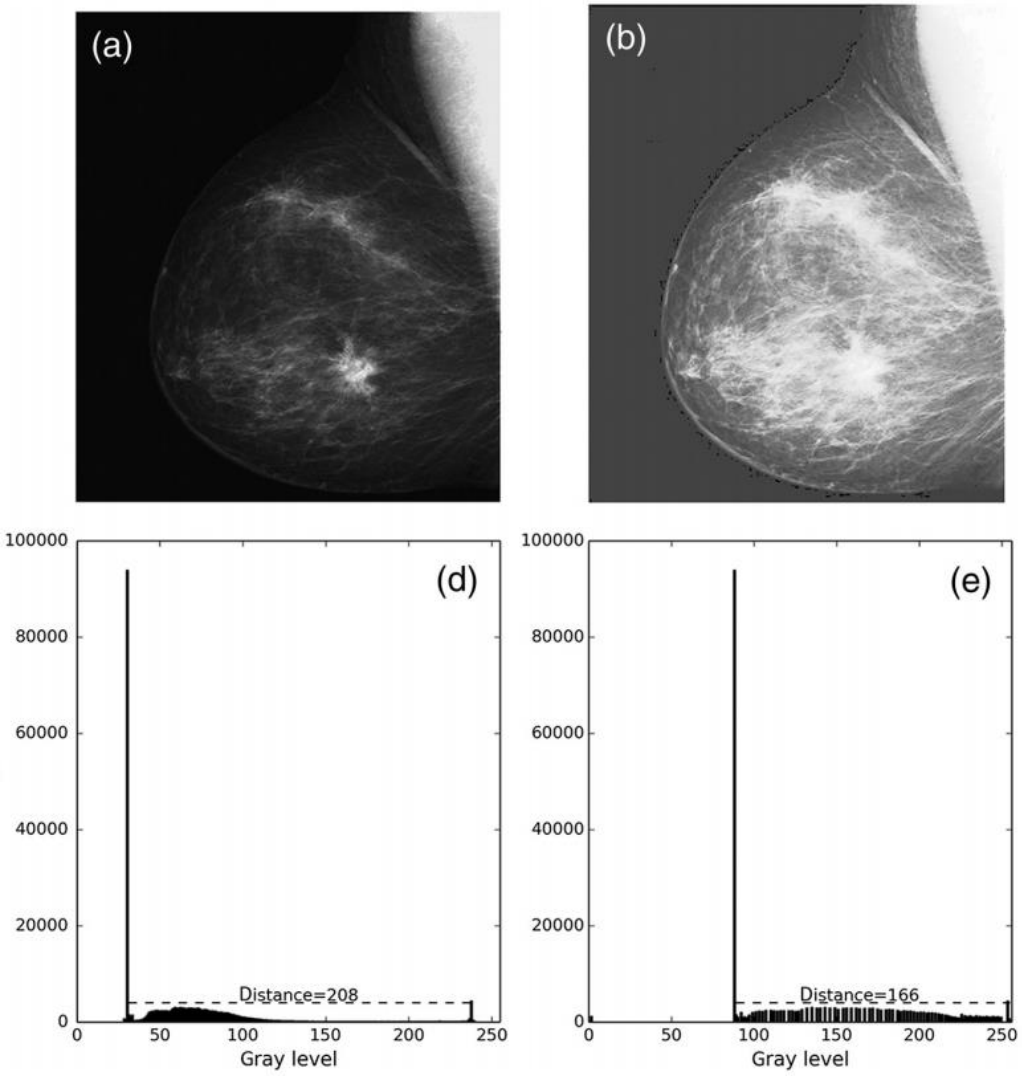
((pixel – min) / (max – min))*255.

Histogram equalization not only stretches histogram, but also tries to make it flat,

http://www.bruzed.com/2009/10/contrast-stretching-and-histogram-equalization/

Why Histogram Equalization?

- Enhance the quality of images (poor contrast images) but not always



Input image (a) has a large area low- intensity background.

Histogram (d) has a spike compon ent corresponding to the backgrou nd gray level.

The output image (b) has a severe washed- out appearance while its dynamic range actually becomes smaller (e).

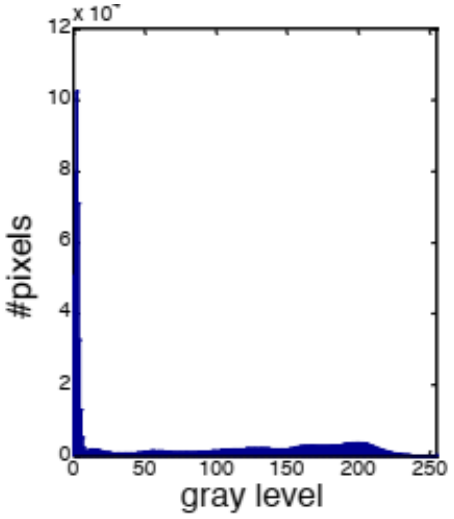
A. Toet et al., Efficient contrast enhancement through log-power histogram modification, J. Elec. Imag., 2014

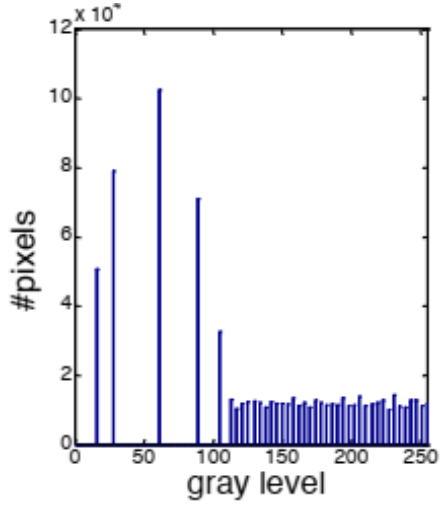
Why Histogram Equalization?

- Enhance the quality of images (poor contrast images) but not always

Original image *Moon*

.. after histogram equalization



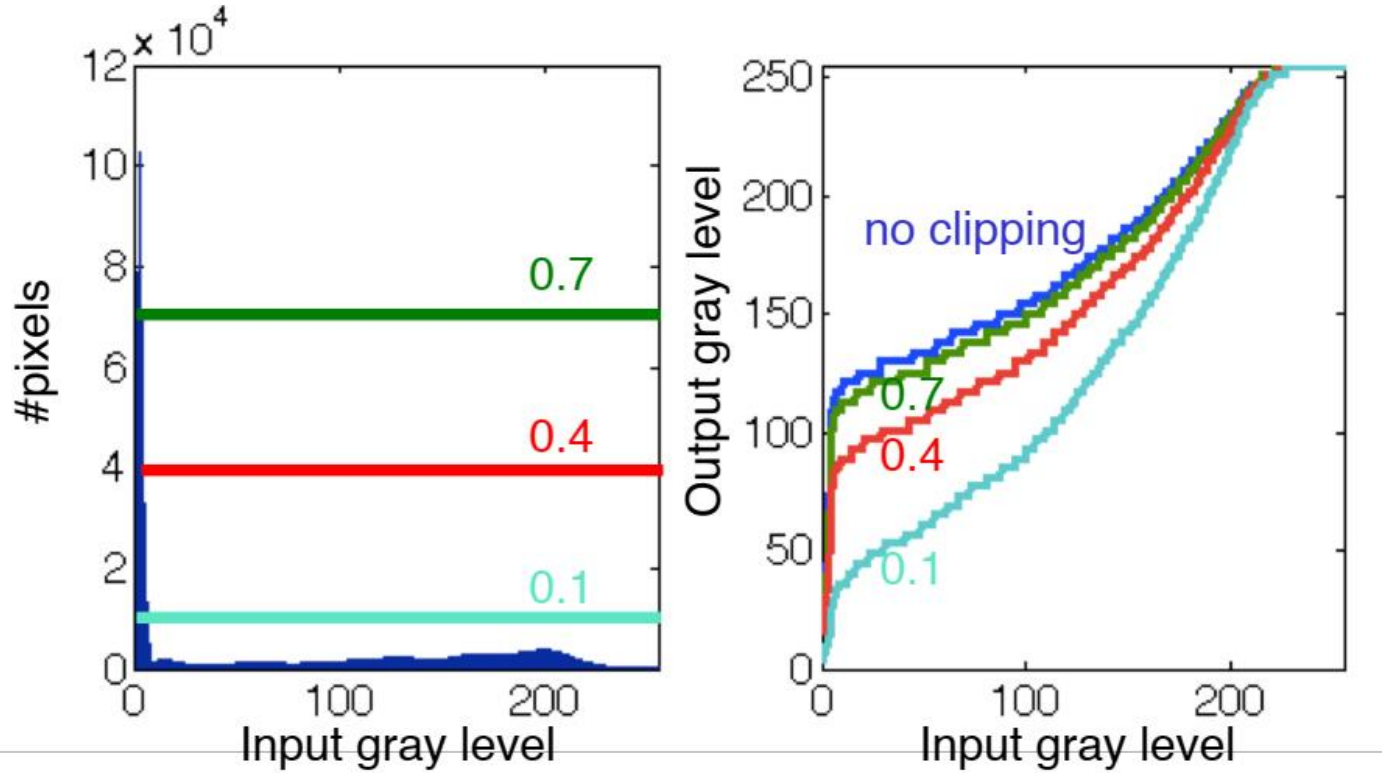


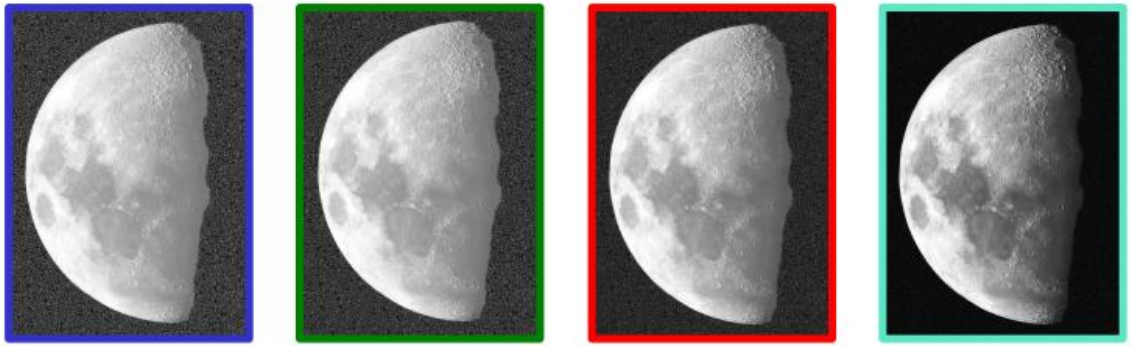
Noise is also enhanced after histogram equalization

Adaptive Histogram Equalization

A. Toet et al., Efficient contrast enhancement through log-power histogram modification, J. Elec. Imag., 2014

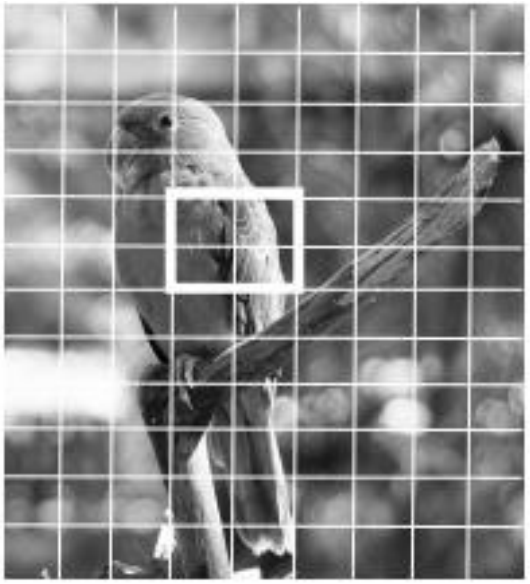
Contrast-Limited Histogram Equalization





Adaptive Histogram Equalization

Sliding window approach:
different histogram (and mapping) for every pixel



Tiling approach:
subdivide into overlapping regions, mitigate blocking effect by smooth blending between neighboring tiles

Limit contrast expansion in flat regions of the image, e.g., by clipping histogram values.
("Contrast-limited adaptive histogram equalization")

Adaptive Histogram Equalization

Original image
Parrot

Global histogram
equalization

Adaptive histogram
equalization, 8x8 tiles

Adaptive histogram
equalization, 16x16 tiles

Adaptive Histogram Equalization

Original image
Dental Xray

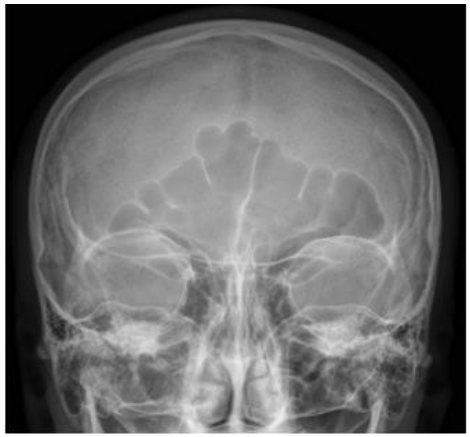
Global histogram
equalization

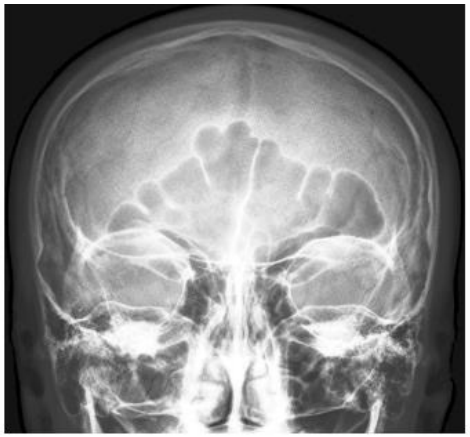
Adaptive histogram
equalization, 8x8 tiles

Adaptive histogram
equalization, 16x16 tiles

Adaptive Histogram Equalization

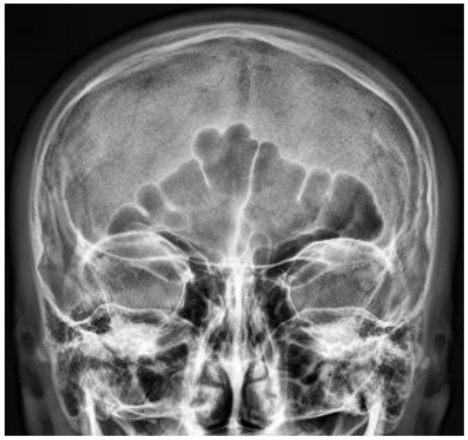
Original image
Skull Xray

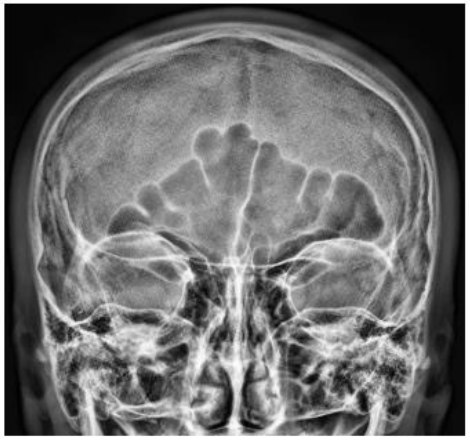




Global histogram equalization

Adaptive histogram equalization, 8x8 tiles

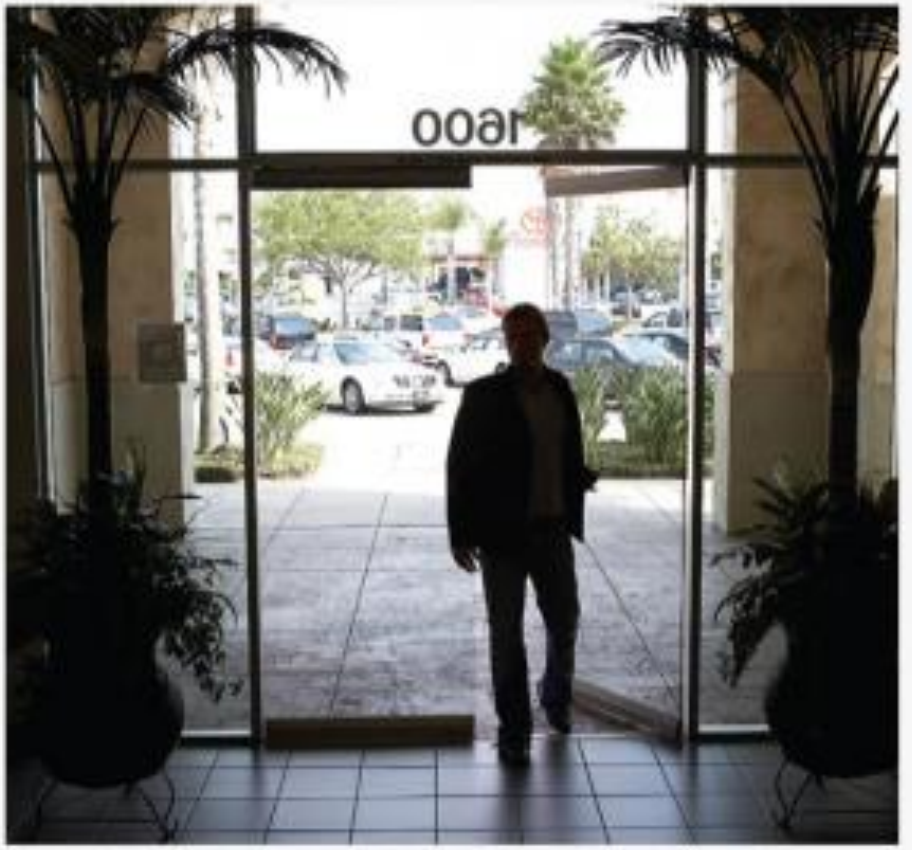




Adaptive histogram equalization, 16x16 tiles

BLC, WDR, DWDR LÀ GÌ?

GOTECH



CAMERA CHỐNG NGƯỢC SÁNG