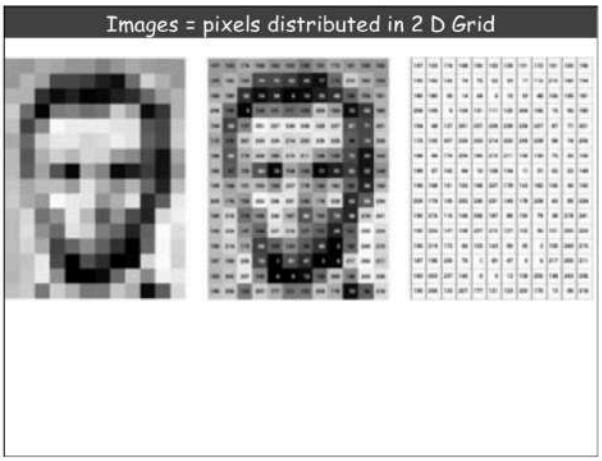
Image Histograms and Image Enhancement



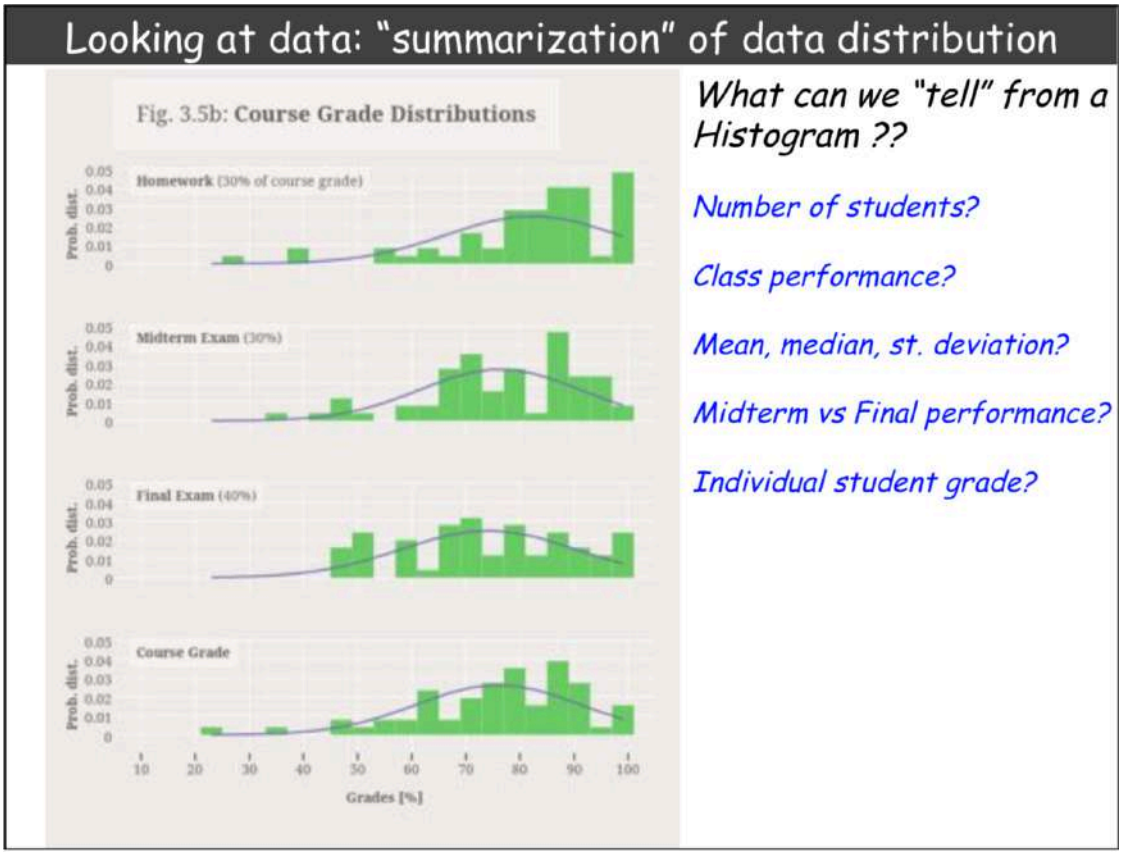
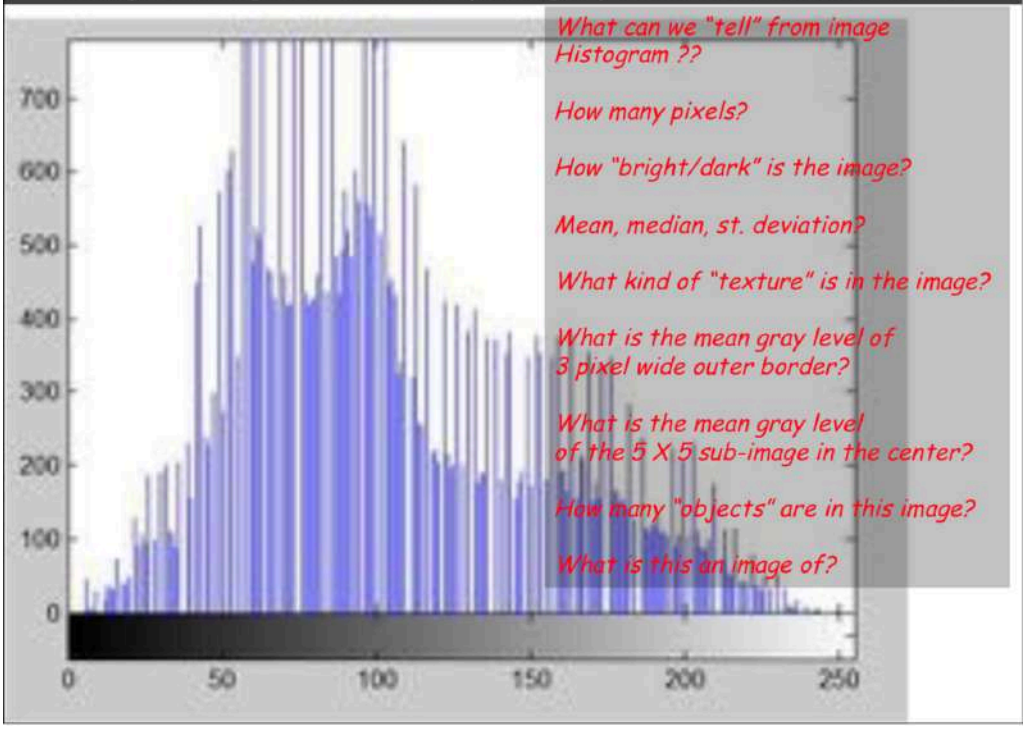


Image Histogram: *How are pixel gray levels are distributed?*



What can we "tell" from image Histogram ??

How many pixels?

How "bright/dark" is the image?

Mean, median, st. deviation?

What kind of "texture" is in the image?

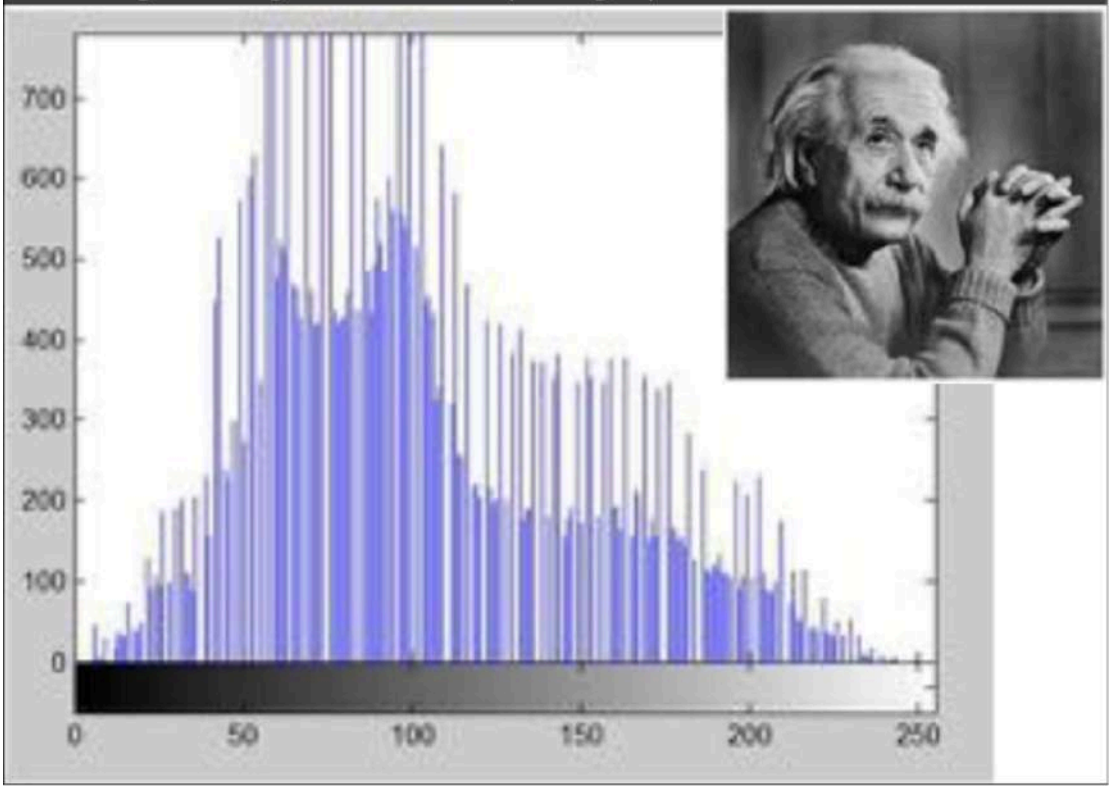
What is the mean gray level of 3 pixel wide outer border?

What is the mean gray level of the 5 X 5 sub-image in the center?

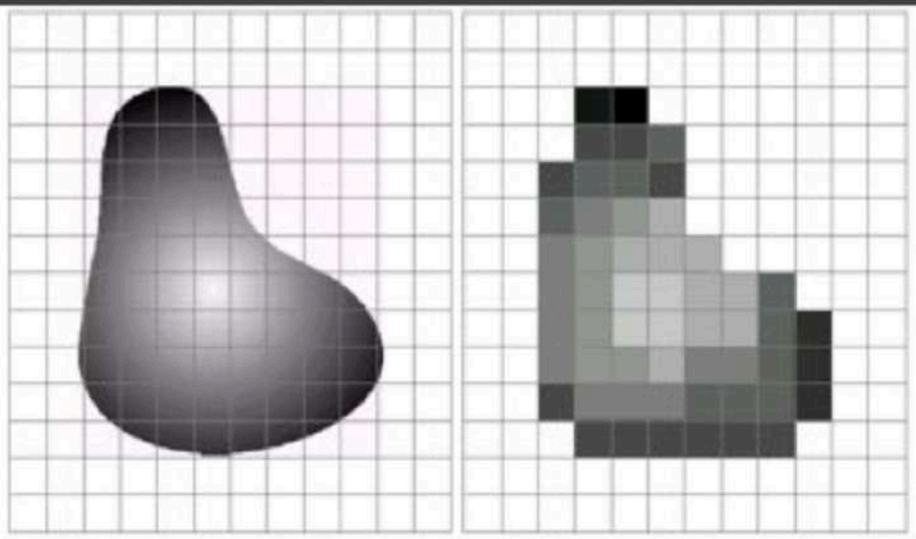
How many "objects" are in this image?

What is this an image of?

Image Histogram: *How are pixel gray levels are distributed?*



Sampling and Quantization



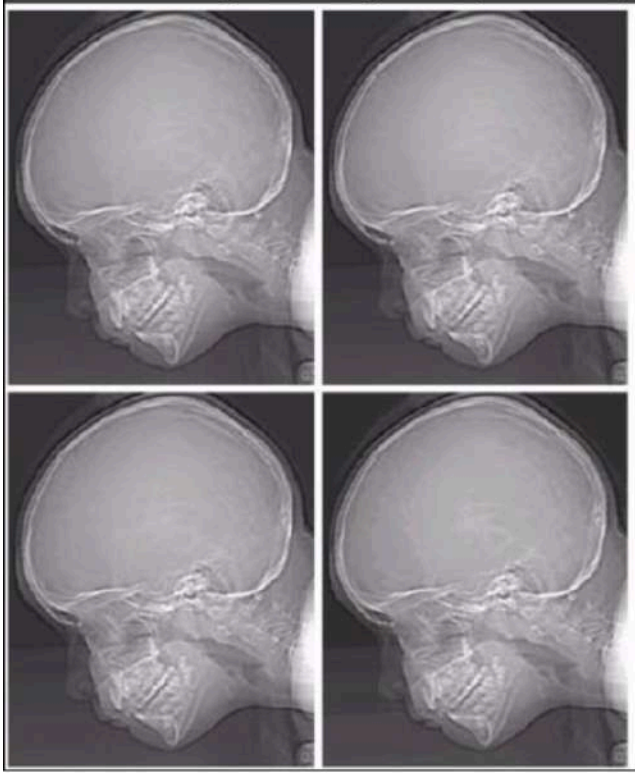
a b

FIGURE 2.17 (a) Continuos image projected onto a sensor array. (b) Result of image sampling and quantization.

Digital Image: *Gray Level Quantization* and Histograms..

Histograms of these images, how would they look ?
Identical? Comparable? ....

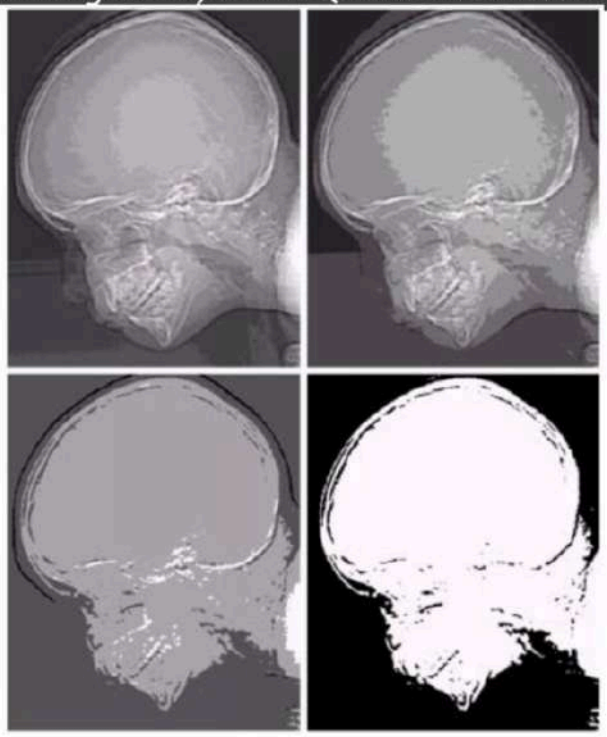
Digital Image: *Gray Level Quantization* Effects



a b
c d

FIGURE 2.21
(a) 452 × 374, 256-level image. (b)–(d) Image displayed in 128, 64, and 32 gray levels, while keeping the spatial resolution constant.

Digital Image: *Gray Level Quantization* Effects



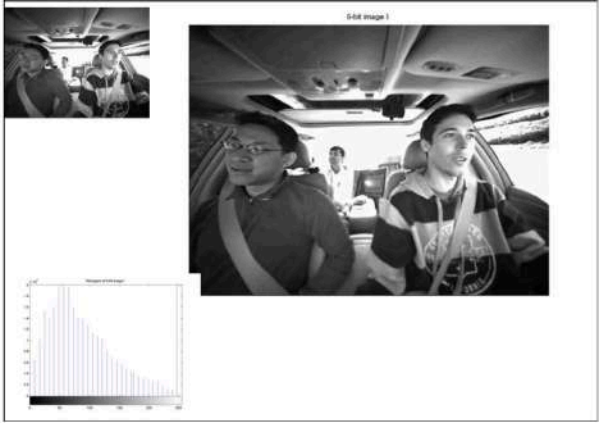
e f
g h

FIGURE 2.21
(Continued)
(e)–(h) Image displayed in 16, 8, 4, and 2 gray levels. (Original courtesy of Dr. David R. Pickens, Department of Radiology & Radiological Sciences, Vanderbilt University Medical Center.)

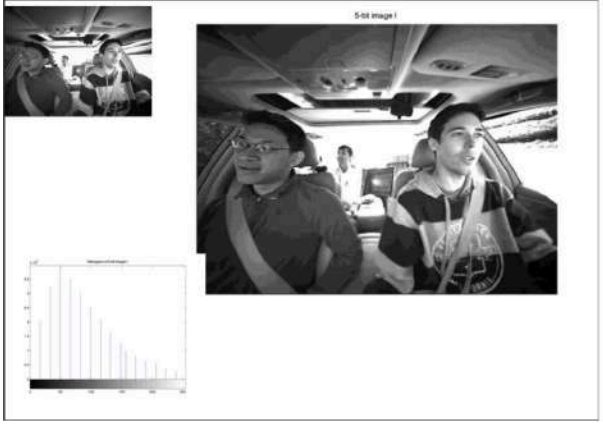
Digital Image: *Gray Level Quantization* Effects

Digital Image: *Gray Level Quantization* Effects

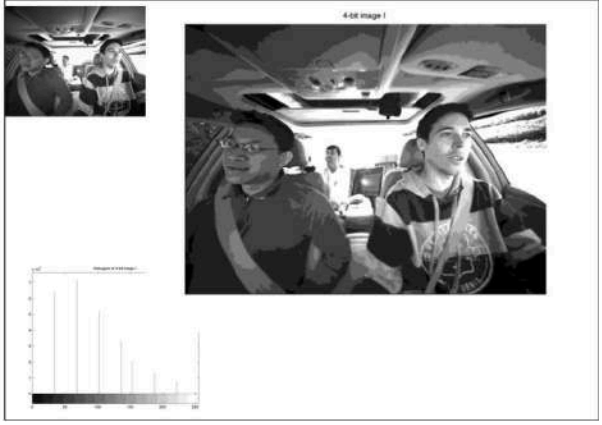
Digital Image: *Gray Level Quantization* Effects



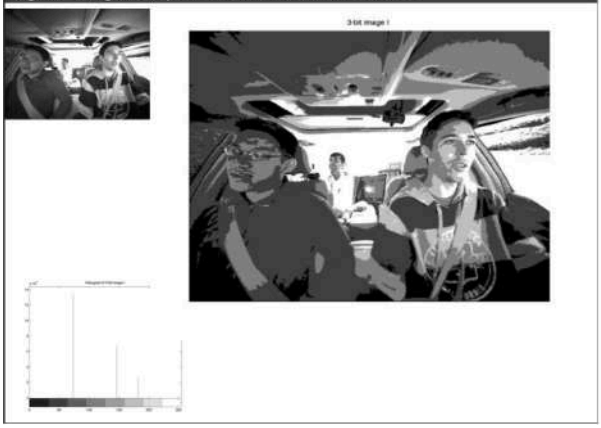
Digital Image: *Gray Level Quantization* Effects



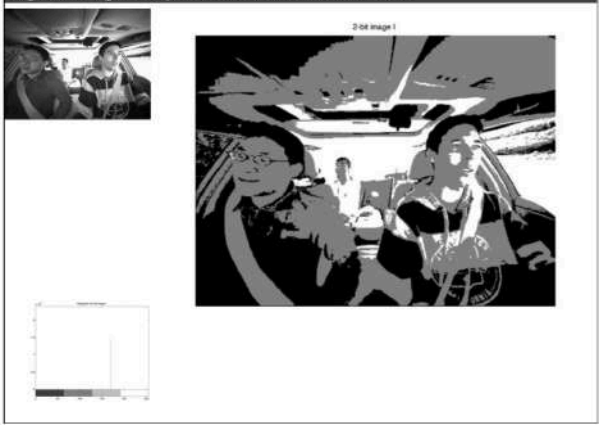
Digital Image: *Gray Level Quantization* Effects



Digital Image: *Gray Level Quantization* Effects



Digital Image: *Gray Level Quantization* Effects

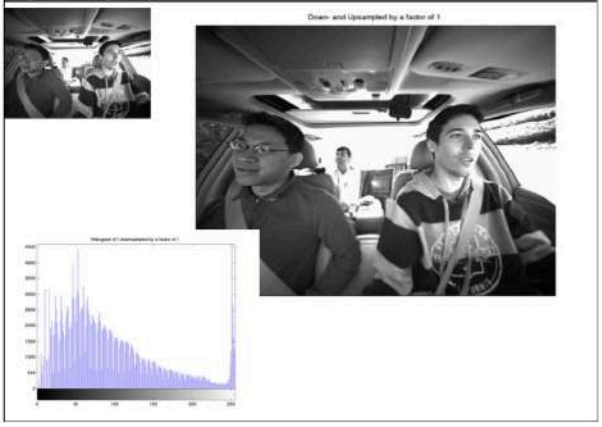


Digital Image: *Gray Level Quantization* Effects

Digital Image: *Spatial Resolution* Effects

Digital Image: *Spatial Resolution* Effects

Digital Image: *Spatial Resolution* Effects

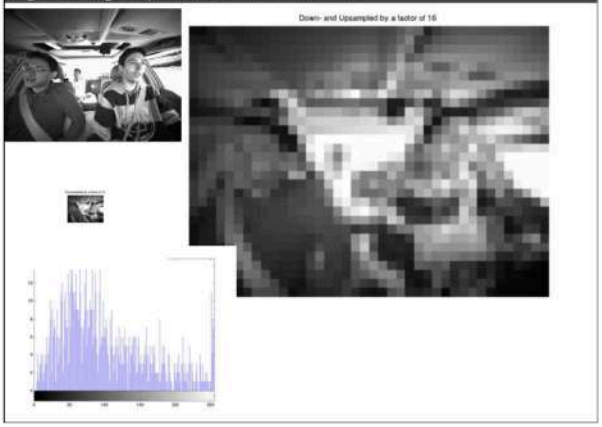


Digital Image: *Spatial Resolution* Effects

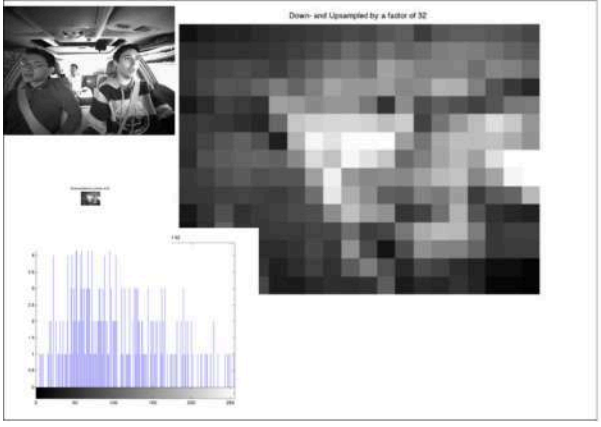
Digital Image: *Spatial Resolution* Effects

Digital Image: *Spatial Resolution* Effects

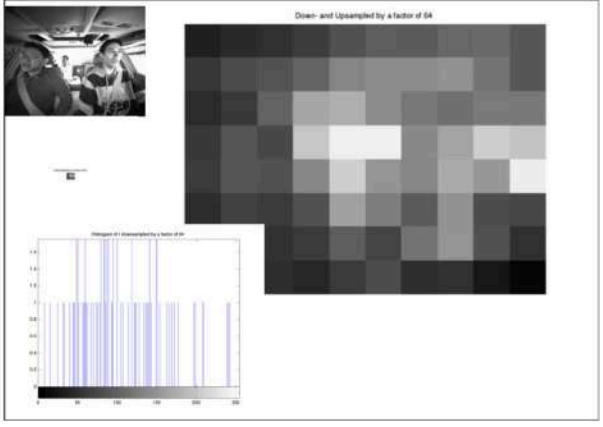
Digital Image: *Spatial Resolution* Effects



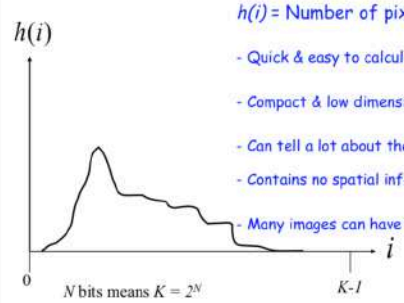
Digital Image: *Spatial Resolution* Effects



Digital Image: *Spatial Resolution* Effects



The Grayscale Histogram



h(i) = Number of pixels with intensity *i*.

- Quick & easy to calculate
- Compact & low dimensional data structure
- Can tell a lot about the image quality
- Contains no spatial info
- Many images can have the same histogram

From: Prof. B. Roysam
Website: http://www.rpi.edu/~roysab
Course Website: http://www.ecse.rpi.edu/censsis/BioCourse

Assessing Image Properties

"Bi-modal" histogram indicates that there are two major kinds of pixels in the image

Perhaps, two kinds of objects in scene - one kind brighter than the other

If we generalize this a bit, we arrive at the idea that a histogram is really a "mixture distribution"

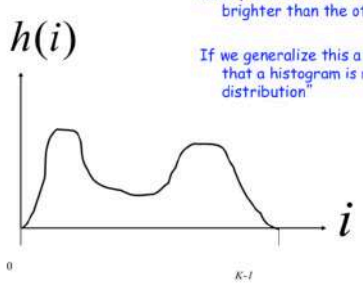


Image "Quality", Image Histograms, Image Enhancement

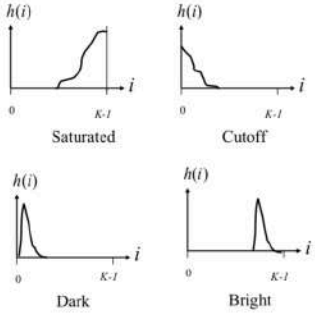
"Understanding image histograms is *probably the single most important concept* to become familiar with when working with pictures from a digital camera.

A histogram can tell you
whether or not your image has been properly exposed,
whether the lighting is harsh or flat, and
what adjustments will work best.

It will *not only improve your skills on the computer*, but as *a photographer as well.*"

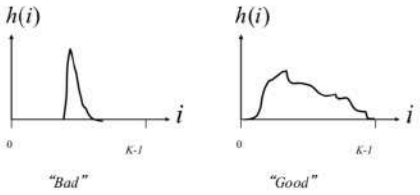
http://www.cambridgeincolour.com/tutorials/histograms1.htm

Assessing Image Quality



From: Prof. B. Roysam
Website: http://www.rpi.edu/~roysab
Course Website: http://www.ecse.rpi.edu/censsis/BioCourse

Assessing Image Quality



"Compact" histogram ➔ poor utilization of available dynamic range

From: Prof. B. Roysam
Website: http://www.rpi.edu/~roysab
Course Website: http://www.ecse.rpi.edu/censsis/BioCourse

Image "Quality", Image Histograms, Image Enhancement

http://gallery.photographyreview.com/showphoto.php?photo=61131&size=big&cat=&perpage=9&sort=2

Image "Quality", Image Histograms, Image Enhancement

http://gallery.photographyreview.com/showphoto.php?photo=61131&size=big&cat=&perpage=9&sort=2

Image "Quality", Image Histograms, Image Enhancement

The region ("dynamic range") where most of the brightness values are present is called the "tonal range."

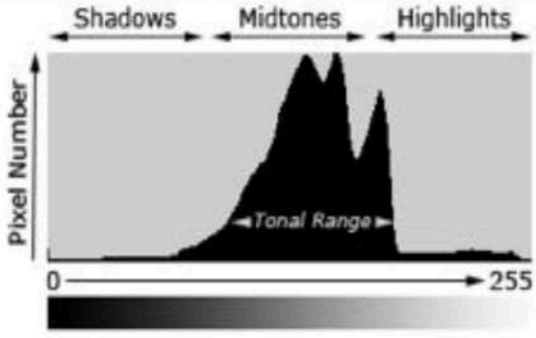
Tonal range can vary drastically from image to image, so developing an intuition for how numbers map to actual brightness values is often critical—both before and after the photo has been taken.

There is no one "ideal histogram" which all images should try to mimic;

histograms should be representative of the tonal range in the scene and what the photographer *(or you the DIP expert*)* wishes to convey.

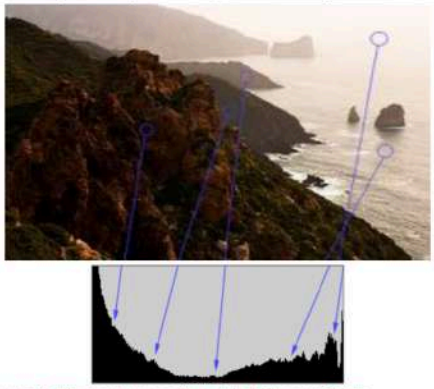
http://www.cambridgeincolour.com/tutorials/histograms1.htm

Image "Quality", Image Histograms, Image Enhancement



http://www.cambridgeincolour.com/tutorials/histograms1.htm

Image "Quality", Image Histograms, Image Enhancement



http://www.cambridgeincolour.com/tutorials/histograms1.htm

Image "Quality", Image Histograms, Image Enhancement

..most cameras will produce midtone-centric histograms when in an automatic exposure mode,

the distribution of peaks within a histogram also depends on the tonal range of the subject matter.

Images where most of the tones occur in the shadows are called "low key,"

whereas with "high key" images most of the tones are in the highlights.

http://www.cambridgeincolour.com/tutorials/histograms1.htm

Image "Quality", Image Histograms, Image Enhancement

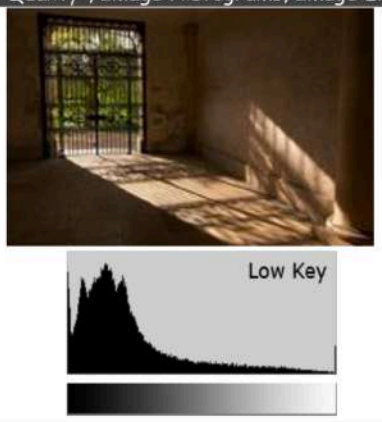


Image "Quality", Image Histograms, Image Enhancement

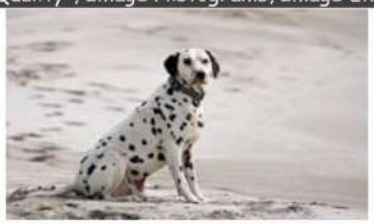
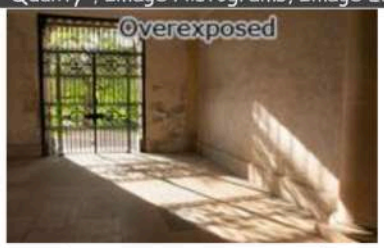
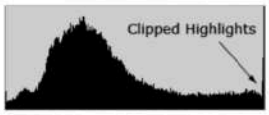


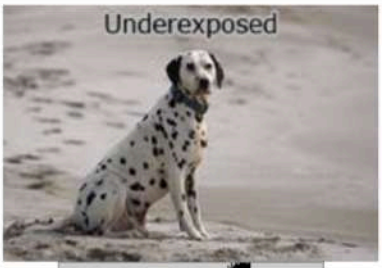
Image "Quality", Image Histograms, Image Enhancement





http://www.cambridgeincolour.com/tutorials/histograms1.htm

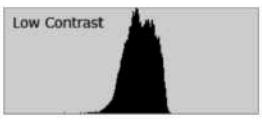
Image "Quality", Image Histograms, Image Enhancement

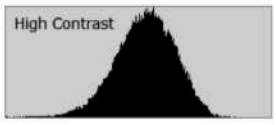


"Saturated"/"Clipped" Image Histograms

http://www.cambridgeincolour.com/tutorials/histograms1.htm

"Contrast" and Image Histograms





http://www.cambridgeincolour.com/tutorials/histograms1.htm

Image "Quality" & Image Histograms

http://media.digitalcameraworld.com/wp-content/uploads/sites/123/2013/06/Photography_histogram_tutorial.jpg

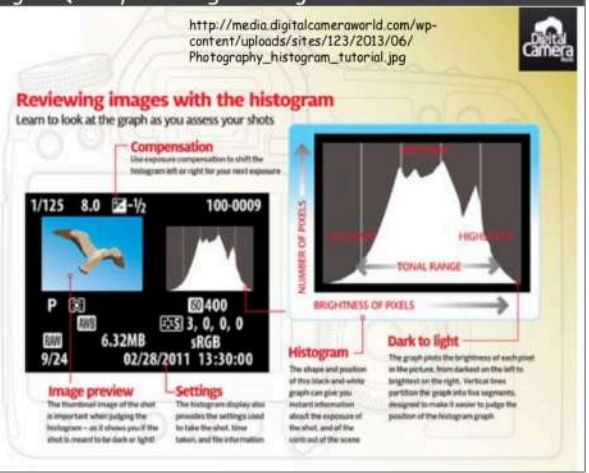
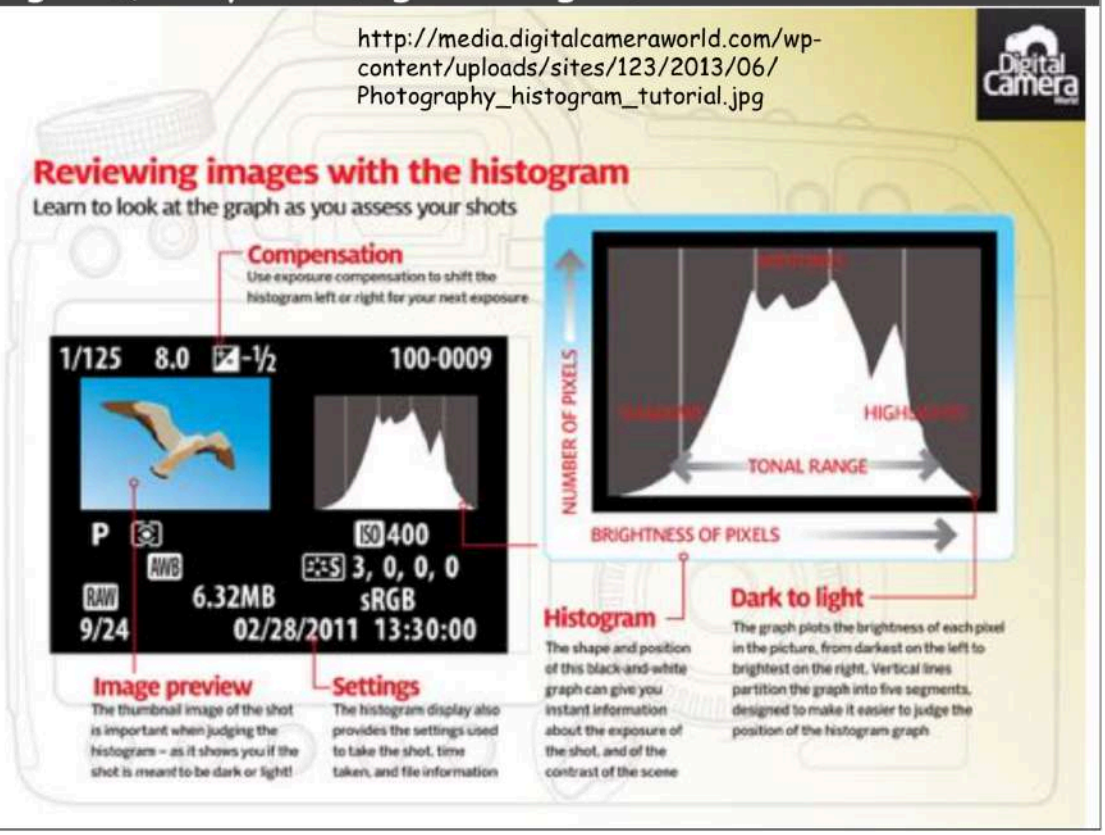
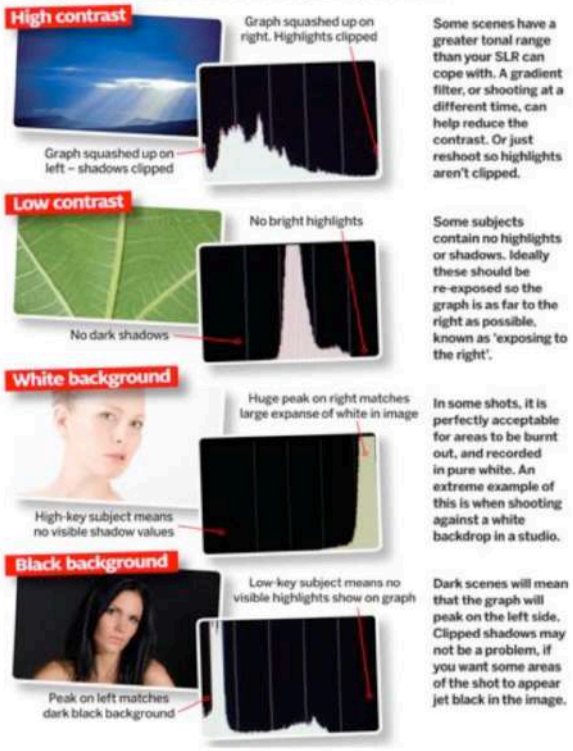


Image "Quality" & Image Histograms

http://media.digitalcameraworld.com/wp-content/uploads/sites/123/2013/06/Photography_histogram_tutorial.jpg

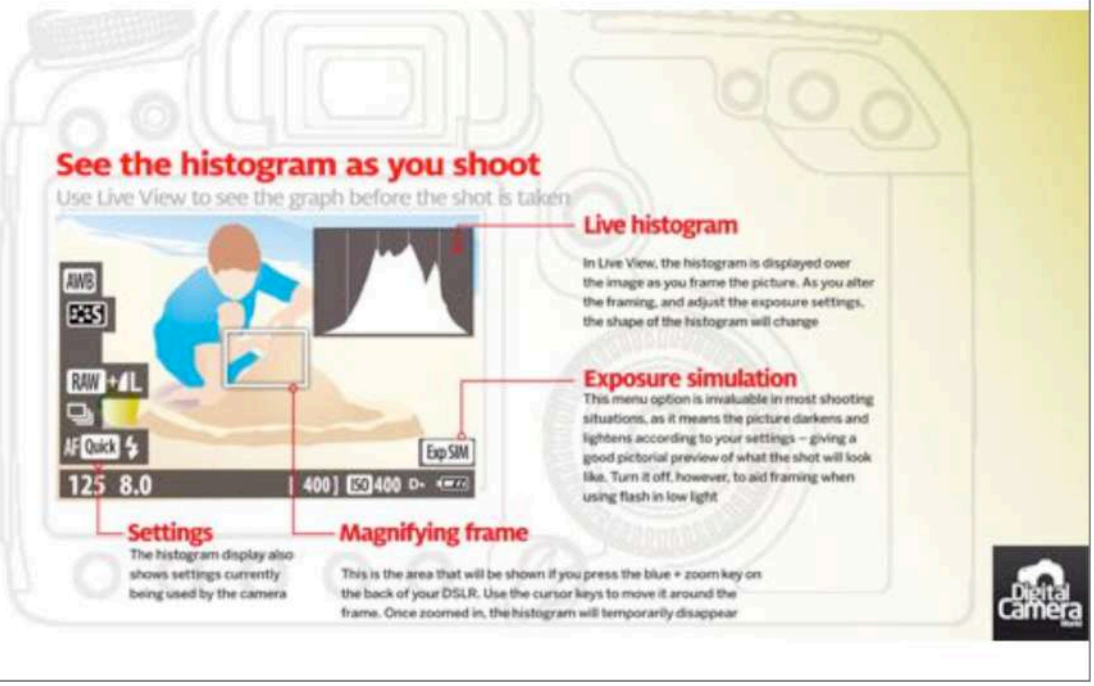


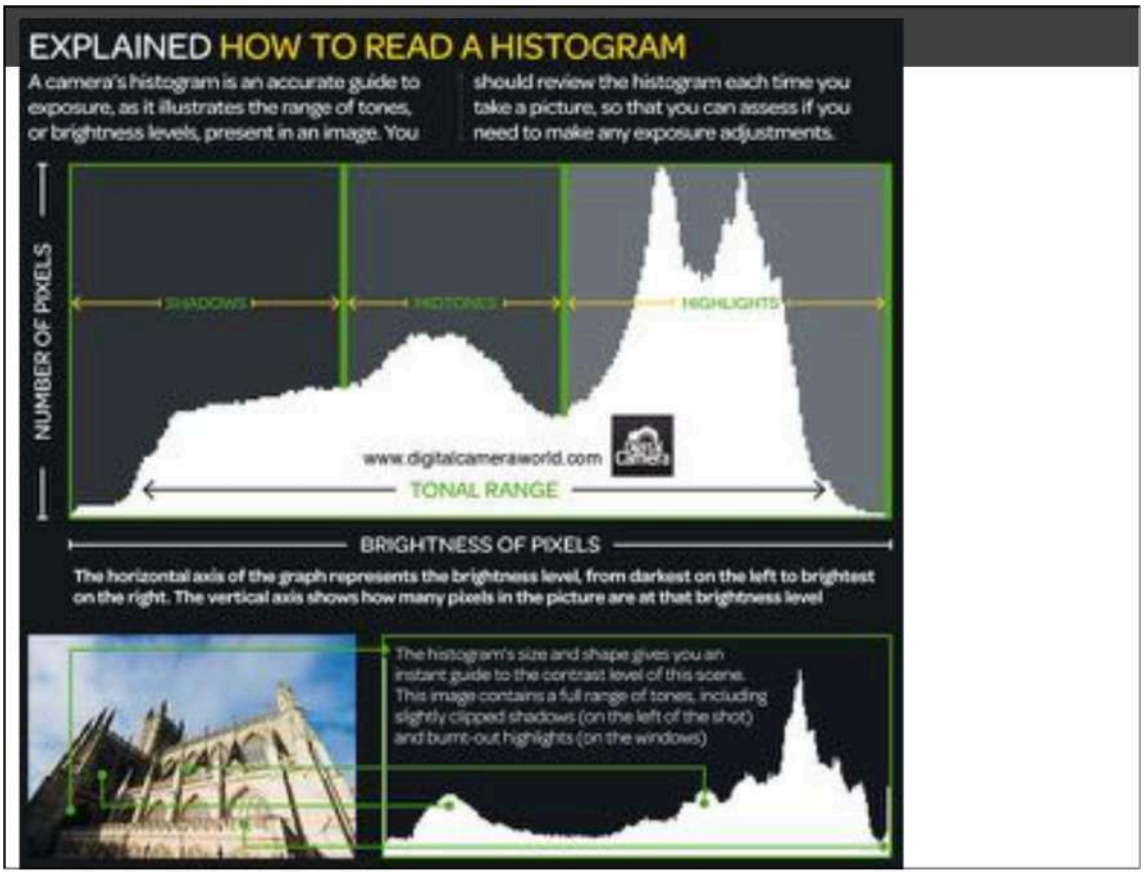
Histograms & Image "Quality"



http://media.digitalcameraworld.com/wp-content/uploads/sites/123/2013/06/Photography_histogram_tutorial.jpg

Image "Quality", Image Histograms, Image Enhancement





Luminosity (or Luminance) Histogram

Luminance* histograms are more accurate than RGB histograms at describing the perceived brightness distribution or "luminosity" within an image. Luminosity takes into account the fact that the human eye is more sensitive to green light than red or blue light. View the above example again for each color and you will see that the green intensity levels within the image are most representative of the brightness distribution for the full color image. This also reflected by the fact that the luminance histogram also matches the green histogram more than any other color. Luminosity correctly predicts that the following stepped gradient gradually increases in lightness, whereas a simple addition of each RGB value would give the same intensity at each rectangle.
Darkest Lightest

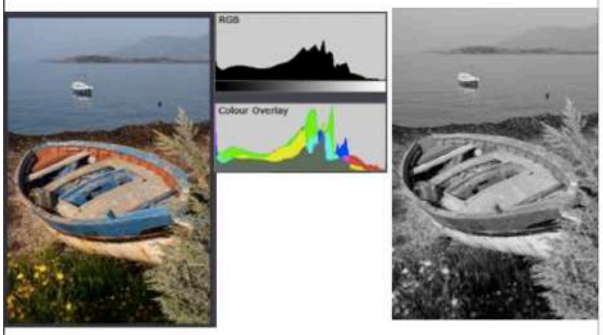
How is a luminance histogram produced? First, each pixel is converted so that it represents a luminosity based on a weighted average of the three colors at that pixel.

This weighting assumes that green represents 59% of the perceived luminosity, while the red and blue channels account for just 30% and 11%, respectively.

http://www.cambridgeincolour.com/tutorials/histograms2.htm

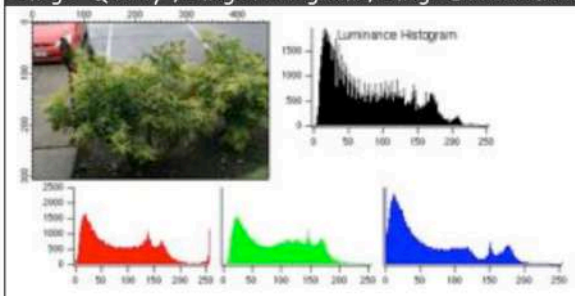
Luminosity (or Luminance) Histogram

This weighting assumes that green represents 59% of the perceived luminosity, while the red and blue channels account for just 30% and 11%, respectively.



http://www.cambridgeincolour.com/tutorials/histograms2.htm

Image "Quality", Image Histograms, Image Enhancement



https://www.wavemetrics.com/products/igorpro/imageprocessing/imagetransforms/histmodification.htm

Digital Image: *Histograms*

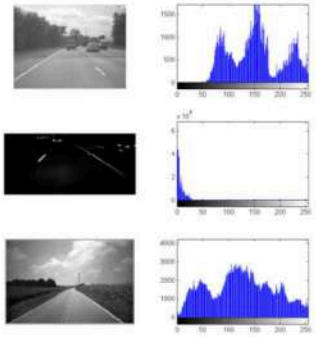


Image Histograms

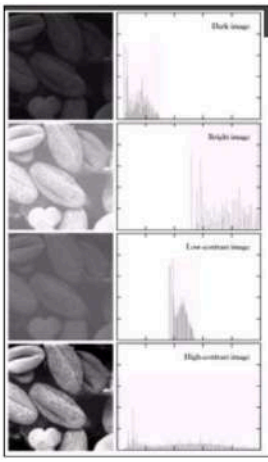
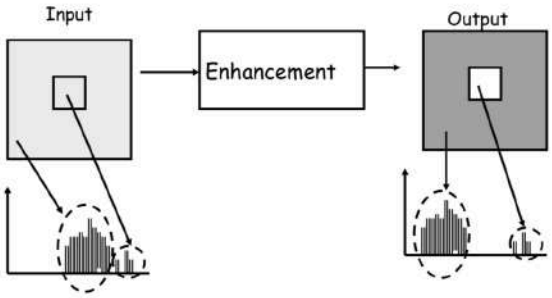
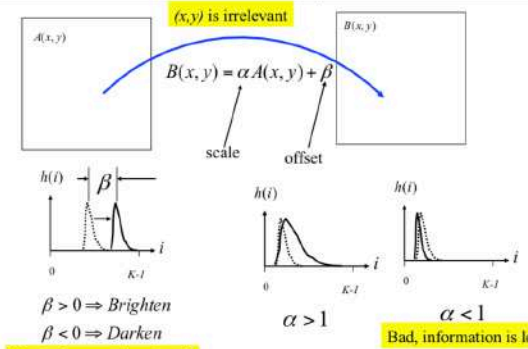


FIGURE 3.15 Four basic image types: dark, light, low contrast, high contrast, and their corresponding histograms. (Original image courtesy of Dr. Roger Heady, Research School of Biological Sciences, Australian National University, Canberra, Australia.)

Spatial Domain Image Enhancement: Basic Idea

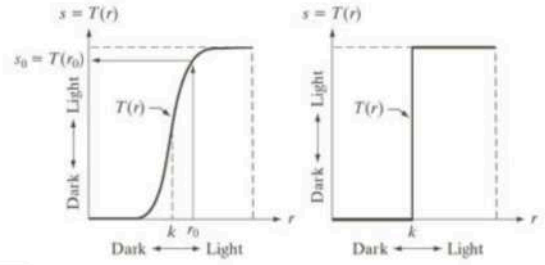


Linear Point Operations



From: Prof. B. Roysam
Website: http://www.rpi.edu/~roysab
Course Website: http://www.ecse.rpi.edu/censsis/BioCourse

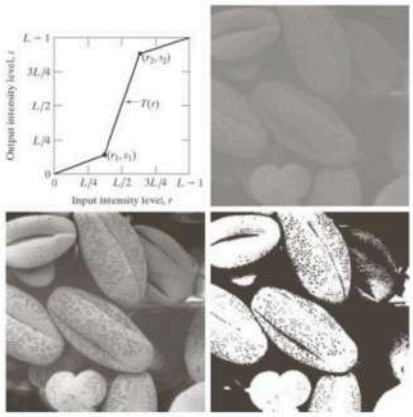
Intensity Transformation Functions



a b

FIGURE 3.2 Intensity transformation functions. (a) Contrast-stretching function. (b) Thresholding function.

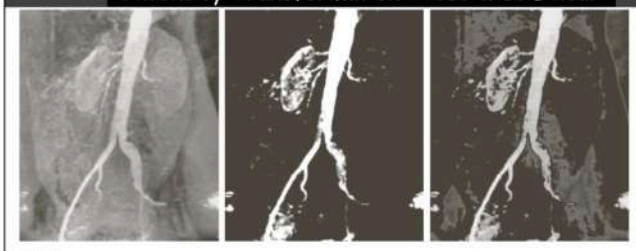
Intensity Transformation: *Contrast Stretching*



a b
c d

FIGURE 3.10 Contrast stretching. (a) Form of transformation function. (b) A low-contrast image. (c) Result of contrast stretching. (d) Result of thresholding. (Original image courtesy of Dr. Roger Heady, Research School of Biological Sciences, Australian National University, Canberra, Australia.)

Intensity Transformation: Piece-wise Linear



a b c

FIGURE 3.12 (a) Aortic angiogram. (b) Result of using a slicing transformation of the type illustrated in Fig. 3.11(a), with the range of intensities of interest selected in the upper end of the gray scale. (c) Result of using the transformation in Fig. 3.11(b), with the selected area set to black, so that grays in the area of the blood vessels and kidneys were preserved. (Original image courtesy of Dr. Thomas R. Gest, University of Michigan Medical School.)

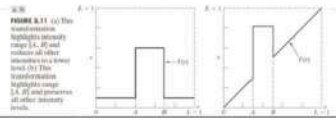
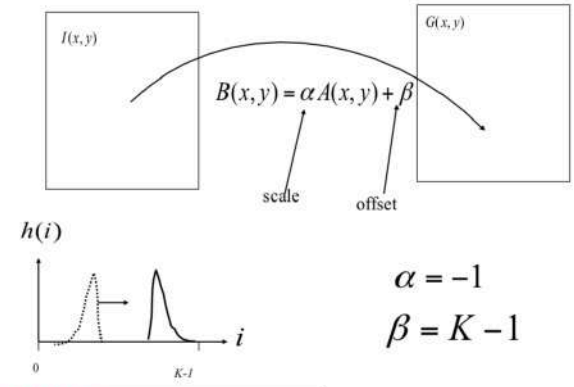


Image Inversion



From: Prof. B. Roysam
Website: http://www.rpi.edu/~roysab
Course Website: http://www.ecse.rpi.edu/censsis/BioCourse

a b

FIGURE 3.11 (a) This transformation highlights intensity range $[A, B]$ and reduces all other intensities to a lower level. (b) This transformation highlights range $[A, B]$ and preserves all other intensity levels.

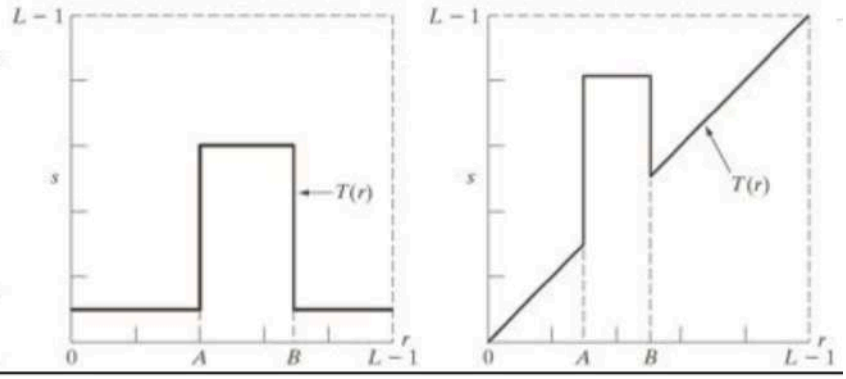
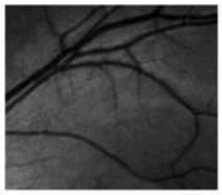
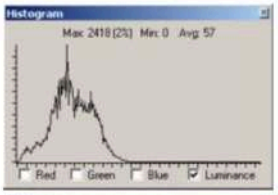
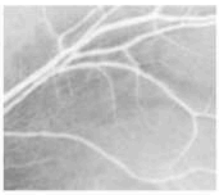
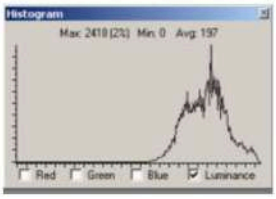


Image Inversion (Negative Image)

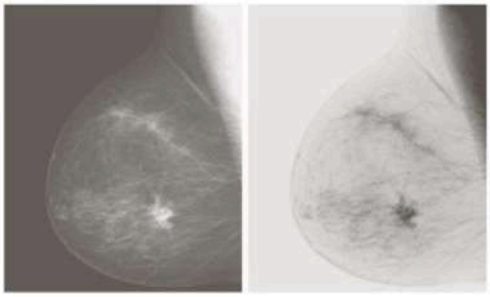








Simple Intensity Transformation Function: *Negative*



a b

FIGURE 3.4
(a) Original digital mammogram. (b) Negative image obtained using the negative transformation in Eq. (3.2-1). (Courtesy of G.E. Medical Systems.)