Image Histogram (Lec 7)

7.1 Introduction:

The histogram of an image is a plot of the gray _levels values versus the number of pixels at that value.

A histogram appears as a graph with "brightness" on the horizontal axis from 0 to 255 (for an 8-bit intensity scale) and "number of pixels "on the vertical axis. For each colored image three histogram are computed, one for each component (RGB, HSL).The histogram gives us a convenient –easy -to -read representation of the concentration of pixels versus brightness of an image, using this graph we able to see immediately:

1) Whether an image is basically dark or light and high or low contrast.

2) Give us our first clues about what contrast enhancement would be appropriately applied to make the image more subjectively pleasing to an observer, or easier to interpret by succeeding image analysis operations. So the shape of histogram provides us information about nature of the image or sub image, For example:

1- Very narrow histogram implies a low-contrast image.
2- Histogram skewed (مائل) to word the high end implies a bright image.
3- Histogram with two major peaks, called bimodal, implies an object that is in contrast with the background.

Not/ One of the principle uses of the histogram is in the selection of threshold parameter.

Algorithm 1.1 shows how we can accumulate in a histogram from an image. Figure 7-1 shows an image and its histogram computed using this algorithm.

ALGORITHM 1.1 Calculating of an image Histogram:

start

Create an array histogram with 26 elements.

For all gray levels, I,do

Histogram [I] =0

Endfor

For all pixels coordinates, x and y, do

Increment histogram [f (x,y)] by 1

Endfor

End

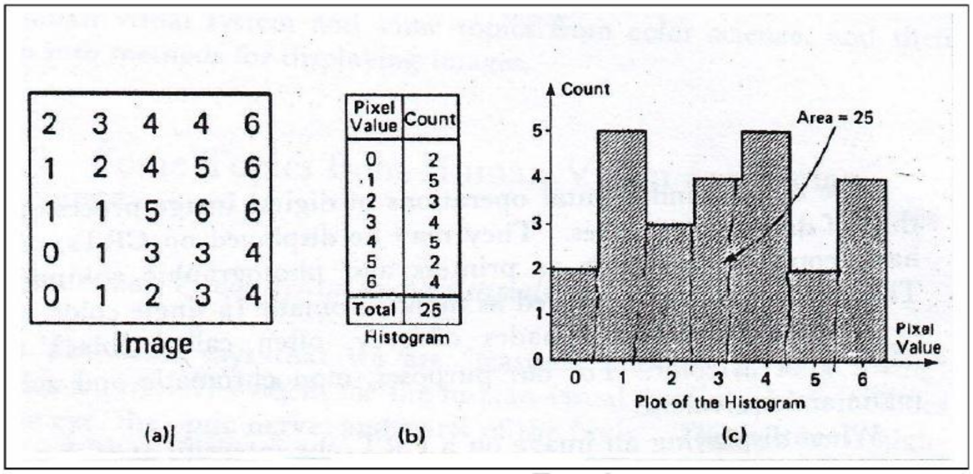


Figure (7-1) image and its histogram computed

7-2 Properties of Histogram:

We can normalize a histogram by dividing the counts in each bin by the total number of pixels in the image associated with that histogram. This gave us a table of estimated probabilities. i.e. probability density function (**pdf**) of the image . The entry for any gray level tells us the likelihood of finding that gray level at pixel selected randomly from the image. Similarly, a normalized cumulative histogram is a table of Cumulative probabilities, i.e, the cumulative distribution function (**CDF**) of the image.

When an image is condensed into a histogram, all spatial information is discarded. The histogram specifies the number of pixels having each gray level but gives no hint as to where those pixels are located within the image. Thus the histogram is unique for any particular image, but the reverse is not true. Vastly different images could have identical histograms. Such operations as moving objects around within an image typically have no effect on the histogram.

7.3 Type of Histogram:

We note in the dark image that the components of the histogram are concentrated on the low (dark) side of the gray scale. Similarly, the components of the histogram of the bright image are biased toward the high side of the gray scale. An image with low contrast has a histogram that will be narrow and will be centered toward the middle of the gray scale. For a monochrome image this implies a dull, washed-out gray look. Finally, we see that the components of the histogram in the high-contrast image cover a broad range of the gray scale and, further, that the distribution of pixels is not too far from uniform, with very few vertical lines being much higher than the others. Intuitively, it is reasonable to conclude that an image, whose pixels tend to occupy the entire range of possible gray levels and, in addition, tend to be distributed uniformly, will have an appearance of high contrast and will exhibit a large variety of gray tones. The net effect will be an image that shows a great deal of gray-level detail and has high dynamic range. It will be shown shortly that it is possible to develop a transformation function that can automatically achieve this effect, based only on information available in the histogram of the input image.

Examples of the different types of histograms are shown in below figure (7-2).

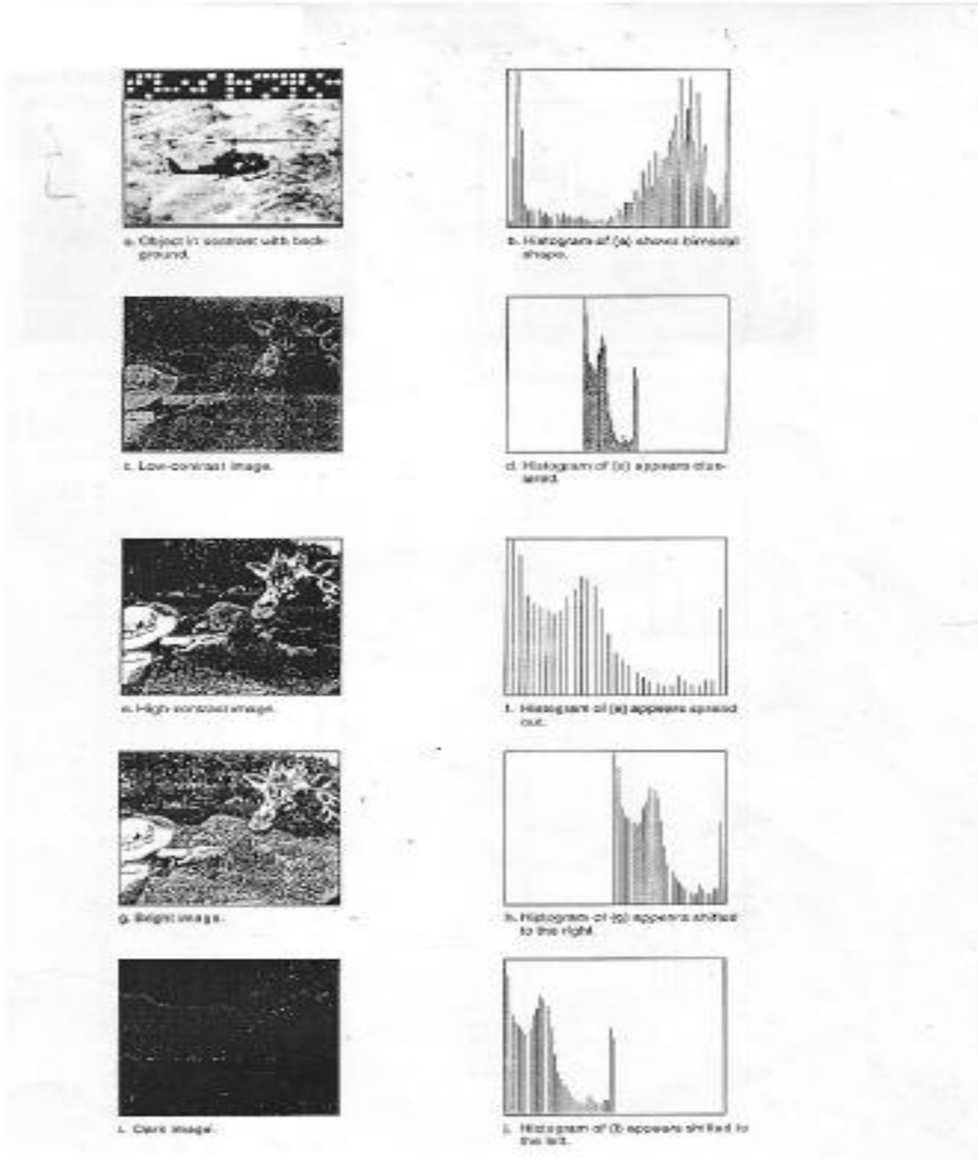


Figure (7-2) different types of histograms

7-4 Histogram Modifications:

The gray level histogram of an image is the distribution of the gray level in an image. The histogram can be modified by mapping functions, which will stretch, shrink (compress), or slide the histogram. Figure (7-3) illustrates a graphical representation of histogram stretch, shrink and slide.

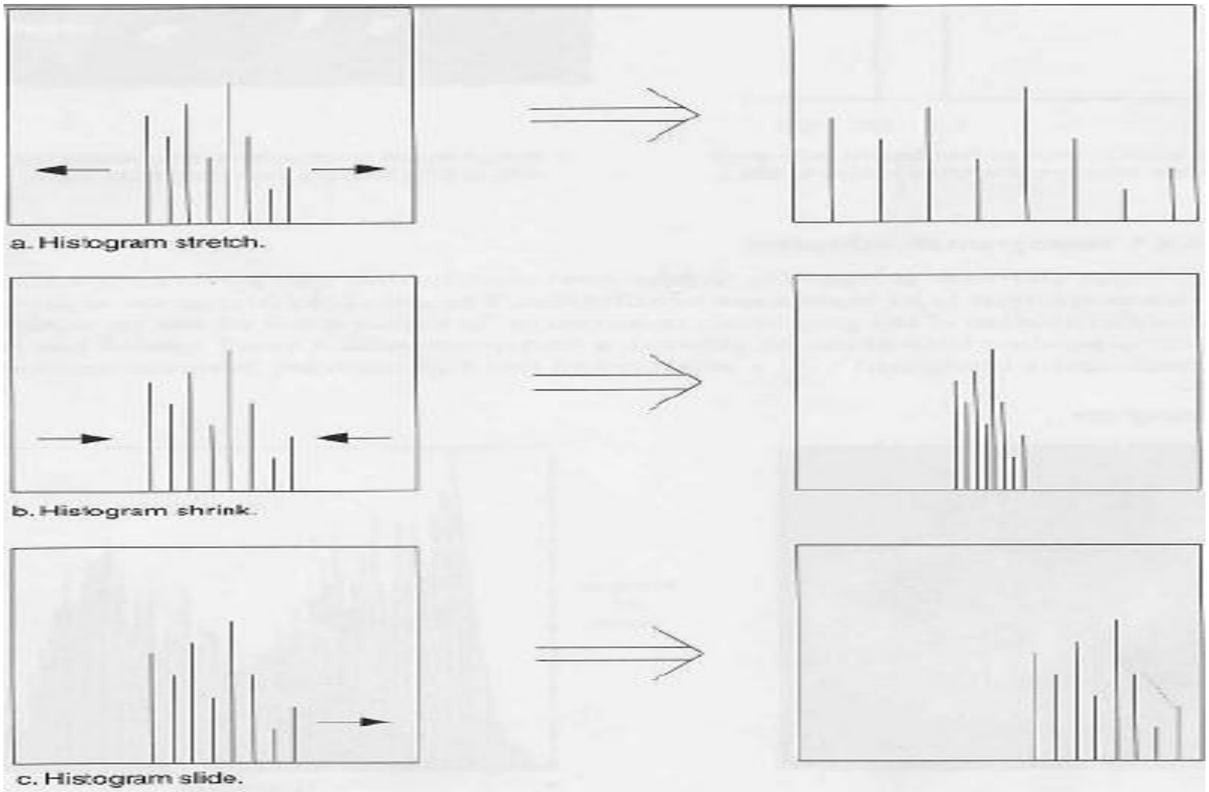


Figure (7-3) histogram modification

• The mapping function for histogram stretch can be found by the following equation:

$$\text{Stretch}\,(I\,(r,c)) = \left[\frac{I(r,c) - I(r,c)_{\min}}{I(r,c)_{\max} - I(r,c)_{\min}}\right][MAX\text{-}MIN] + MIN.$$

Where, **I(r,c)** max is the largest gray- level in the image **I(r,c).**
I(r,c) min is the smallest gray- level in the image **I(r,c).**
MAX and **MIN** correspond to the maximum and minimum gray – level values possible (for an 8-bit image these are 255 and 0).

This equation will take an image and stretch the histogram across the entire gray-level range which has the effect of increasing the contrast of a **low contrast** image (see figure (7-4) of histogram stretching).

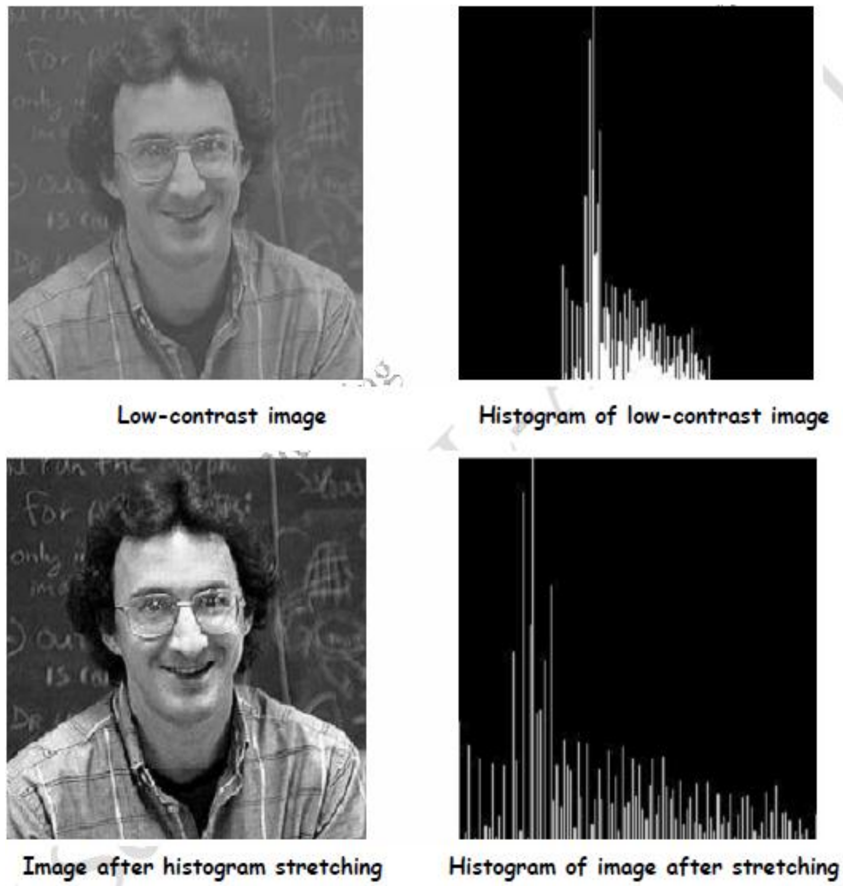


Figure (7-4) Histogram stretching

In most of the pixel values in an image fall within small range, but a few outlines force the histogram to span the entire range, a pure histogram stretch will not improve the image. In this case it is useful to allow a small proceeding of the pixel values to be clipped at the low and high end of the range (for an 8-bit image this means truncating at **0** and **255**). See figure (7-5) of stretched and clipped histogram).

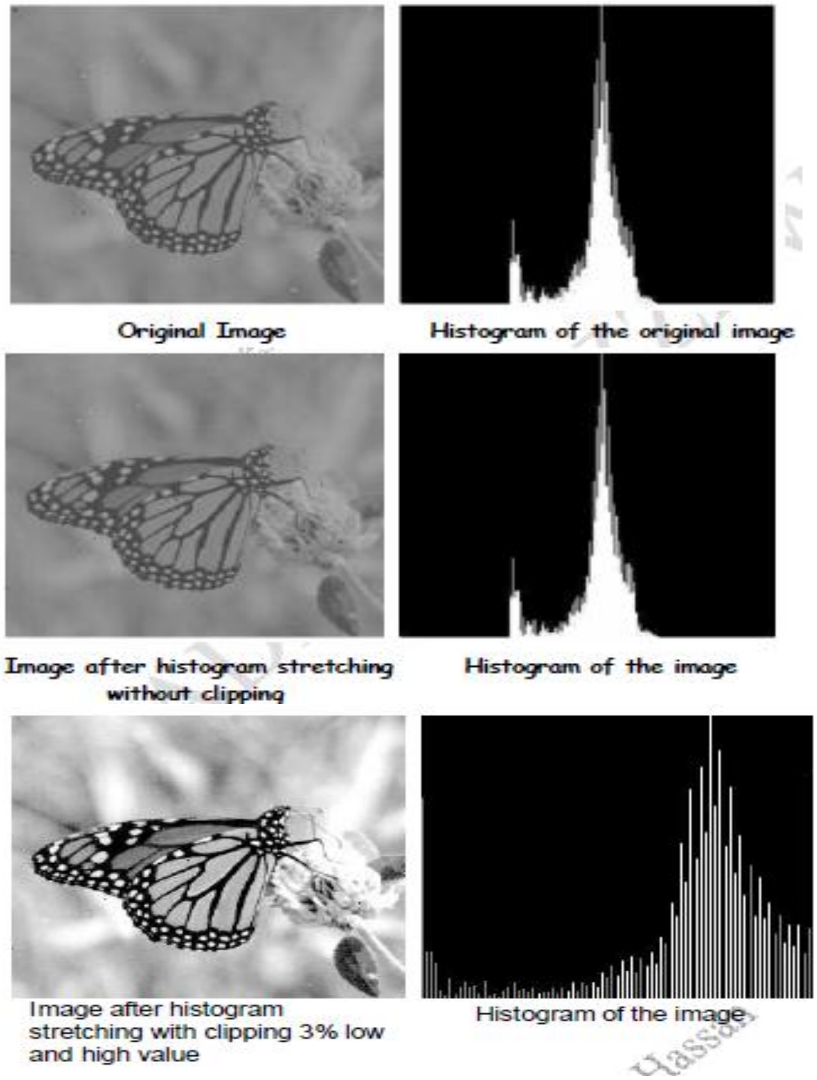
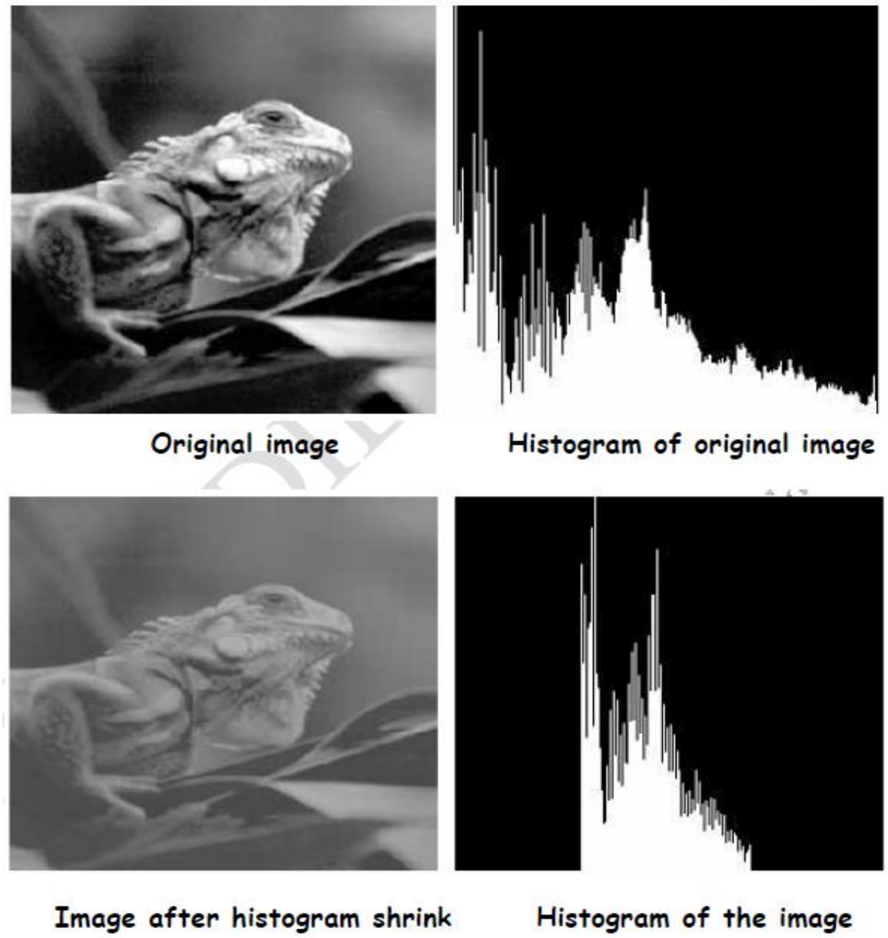


Figure (7-5) stretched and clipped histogram

• The opposite of a histogram stretch is a histogram shrink, which will decrease image contrast by compressing the gray levels. The mapping function for a histogram shrinking can be found by the following equation:

$$\text{Shrink}\,(I(r,c)) = \left[\frac{Shrink_{\max} - Shrink_{\min}}{I(r,c)_{\max} - I(r,c)_{\min}}\right]\left[I(r,c) - I(r,c)_{\min}\right] + Shrink_{\min}$$

Shrink $_{max}$ and **shrink** $_{min}$ correspond to the maximum and minimum desired in the compressed histogram. In general, this process produces an image of reduced contrast and may not seem to be useful an image enhancement (see figure (7-6) of shrink histogram).

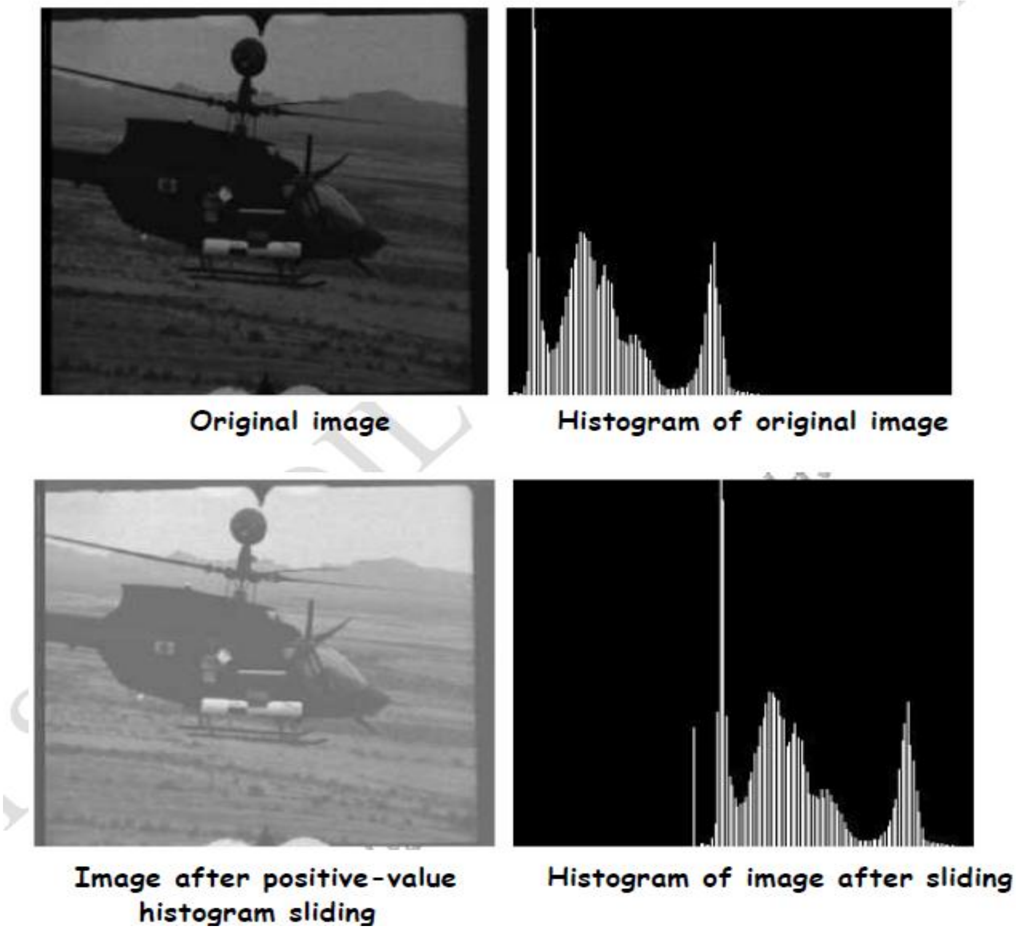


Figurer (7-6) Histogram Shrinking

• The histogram slide techniques can be used to make an image either darker or lighter but retain the relationship between gray-level values.
This can be a accomplished by simply adding or subtracting a fixed number for all the gray-level values, as follows:

Slide (I(r,c)) = I (r,c)+ OFFSET.

Where OFFSET values is the amount to slide the histogram. In this equation, a positive OFFSET value will increase the overall brightness; whereas a negative OFFSET will create a darker image, figure (6-7) shows histogram sliding



Figurer (7-7) Histogram Sliding