Segmentation

Segmentation is a partitioning of an image I into non-intersecting, connected, groups of pixels (regions) such that:

I is the union of all regions.

Each region is homogenous , or uniform .

The union of no two adjacent regions is homogeneous.

All pixels belonging to a region have a unique index.

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Segmentation (cont.)

This definition is general. It includes both meaningful & meaningless segmentations depending on the interpretation of uniform .

A segmentation is <u>meaningful</u> if the resulting segments correspond to observable objects or logical parts of objects.

Segmentation is usually based on contrast, edges, texture and/or any combination of these properties.

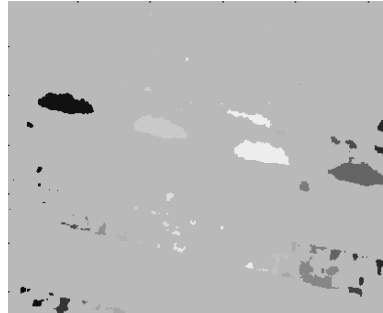Meaningful segmentation is, unfortunately, a vague notion.

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Segmentation Examples

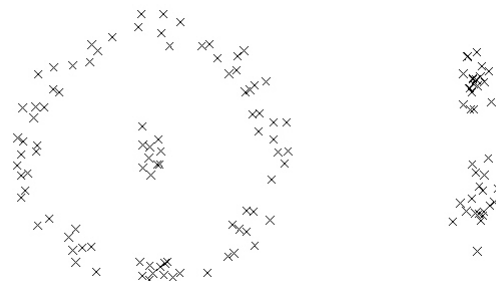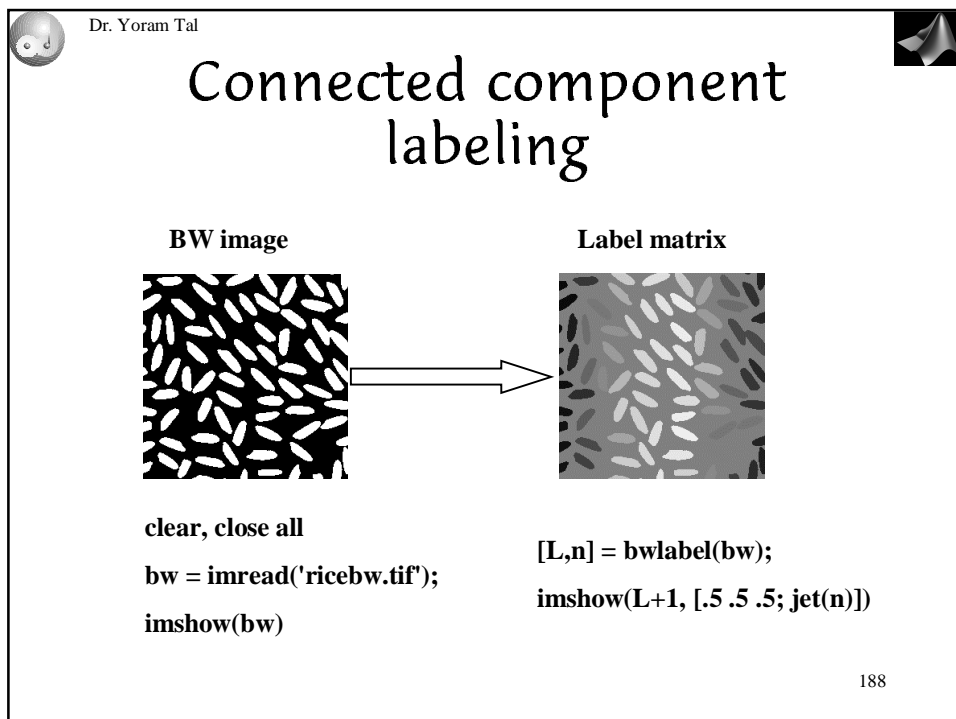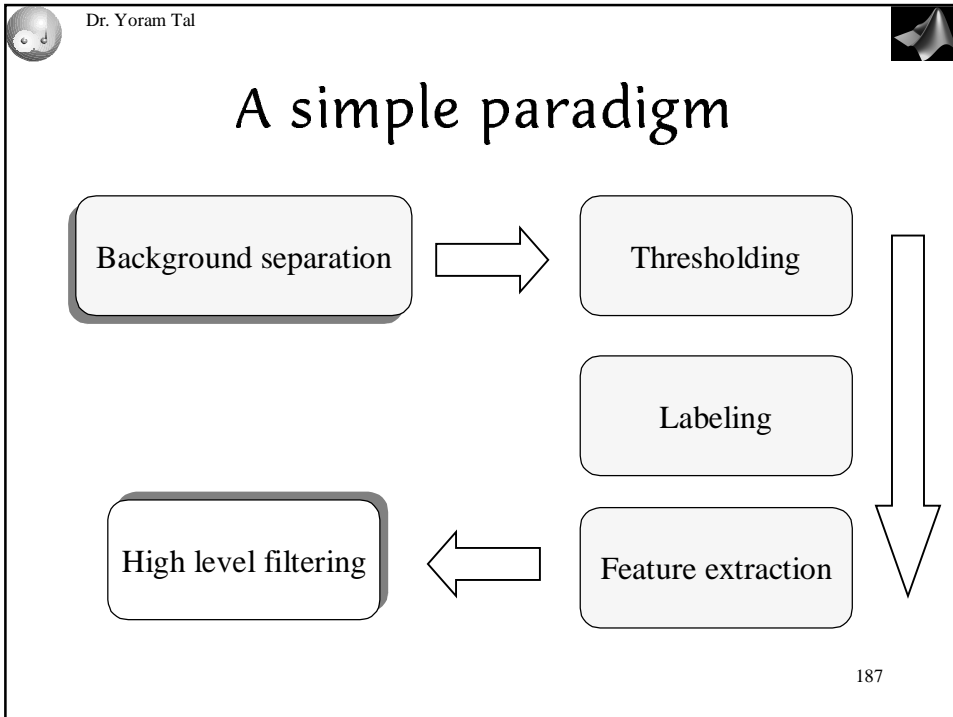Each segment has a unique index, represented by a unique color

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Segmentation Problem

Segmentation is an ill posed problem equivalent,
in some sense, to the <u>clustering</u> problem:

How many clusters?

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A simple paradigm

Background separation → Thresholding

Labeling

High level filtering ← Feature extraction

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Connected component labeling

BW image

Label matrix

clear, close all

bw = imread('ricebw.tif');

imshow(bw)

[L,n] = bwlabel(bw);

imshow(L+1, [.5 .5 .5; jet(n)])

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Feature computation
Centroid
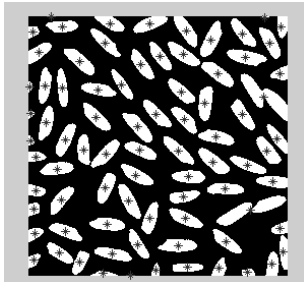
stats = imfeature(L,'Centroid','BoundingBox');

imshow(bw)

centro = [stats.Centroid];

hold on

plot(centro(1:2:end), centro(2:2:end), 'r*')

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Bounding box computation
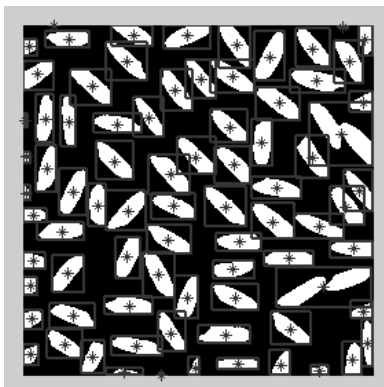
for k = 1:n

    bbox = stats(k).BoundingBox;

    x1 = bbox(1);

    y1 = bbox(2);

    x2 = x1 + bbox(3);

    y2 = y1 + bbox(4);

    x = [x1 x2 x2 x1 x1];

    y = [y1 y1 y2 y2 y1];

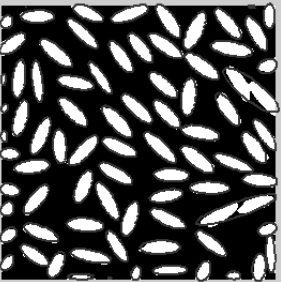   **plot(x,y,'r','LineWidth',2)**

end

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Ellipsoid approximation

```
stats2 = imfeature(L,'MajorAxisLength ,' ...
         MinorAxisLength','Orientation')

close all;  imshow(bw),   hold on
phi = linspace(0,2*pi,50);
cos_phi = cos(phi);
sin_phi = sin(phi);
```

Loop through all segments:
```
xbar = stats(k).Centroid(1);
ybar = stats(k).Centroid(2);
a = stats2(k).MajorAxisLength/2;
b = stats2(k).MinorAxisLength/2;

theta = pi*stats2(k).Orientation/180;
R = [ cos(theta)   sin(theta);
     -sin(theta)   cos(theta)];
xy = R*[a*cos_phi; b*sin_phi];
x = xy(1,:) + xbar;  y = xy(2,:) + ybar;

plot(x,y,'r','LineWidth',2,'Clipping','off );
```

Blob Filtering

Marginal blobs
(bounding box close to the
image boundary)
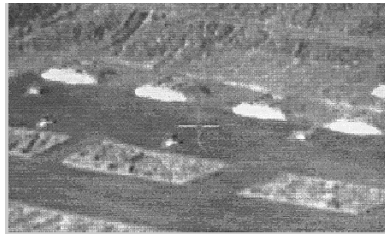
Size
(too small or too large)

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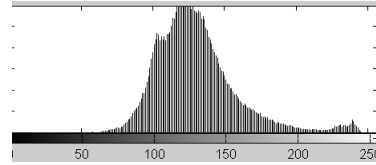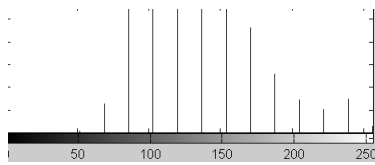# IR Image Segmentation

Source image   Smoothed image

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Thresholding & Labeling

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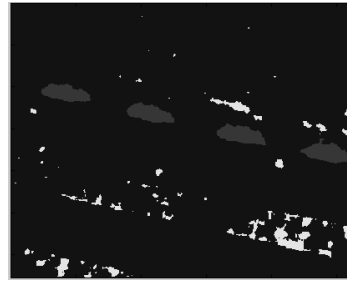# Blob Filtering

Area   Mean graylevel

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Contouring

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4.5.2 Application to the correction of uneven illumination

An illumination gradient occurs when a scene is unevenly illuminated. There is a need for correcting this effect because grey scale measurements and global threshold techniques cannot be applied to images of unevenly illuminated scenes. The best solution is to optimise the lighting system so as to acquire evenly illuminated images but still this is impossible in many practical situations. For instance, the background 'illumination' of an x-ray image of a manufactured metallic part of uneven width is directly proportional to the width of this part and is therefore uneven: the larger the width, the darker the output intensity level. If the image objects have all the same local contrast, i.e., if they are either all darker or brighter than the background, top-hat transforms can be used for mitigating illumination gradients. Indeed, a top-hat with a large isotropic structuring element acts as a high-pass filter. As the illumination gradient lies within the low frequencies of the image, it is removed by the top-hat. White top-hats are used for dark backgrounds and black top-hats for bright backgrounds. For example, the upper left image of Fig. 4.18 presents an increasing illumination from left to right. Global
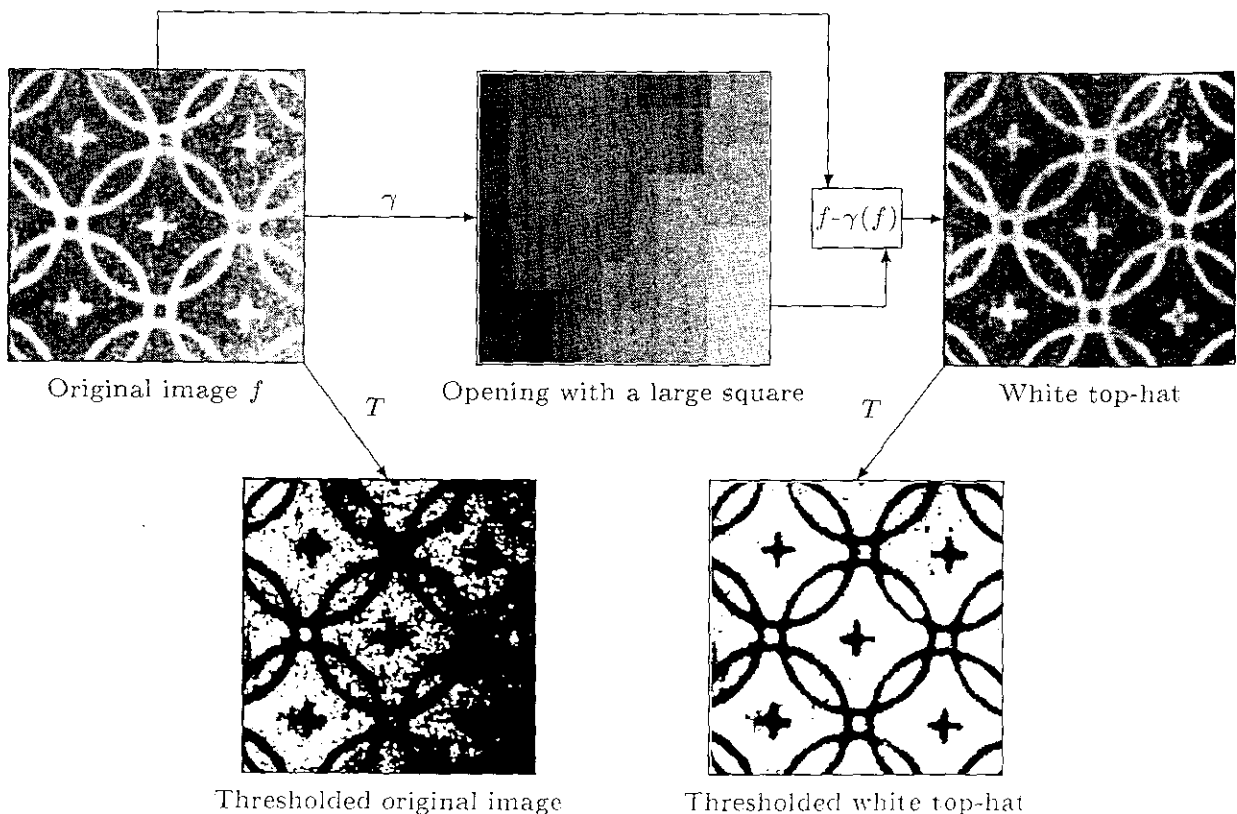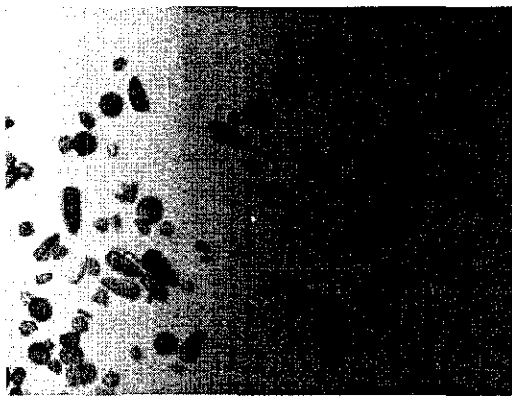

Original image f Opening with a large square   White top-hat

Thresholded original image   Thresholded white top-hat

Fig. 4.18. Use of top-hat for mitigating inhomogeneous illumination. The performance of this technique is illustrated by the thresholds on the original and top-hat images.

thresholding techniques fail to extract a mask of the rings and crosses on this image as shown in the bottom left image. An opening of the original image with a large square SE removes all relevant image structures but preserves the

illumination function. The white top-hat of the original image or subtraction of the illumination function from the original image outputs an image with a homogeneous illumination. A global threshold of the white top-hat succeeds in extracting relevant image structures as shown in the bottom left image. The removal of the uneven illumination function of the watermark shown in table 1.1, p. 5, has been achieved with the same technique.

If the contrast between the objects and the background is decreasing when the background is darkening, a better visual rendering may be obtained by dividing the input image by the closing (or opening). This is illustrated in Fig. 4.19 for a very badly illuminated image of seeds. A closing with a large structuring element removes the seeds but preserves the illumination function. The black top-hat or subtraction of the original image from the closing provides us with an evenly illuminated image (Fig. 4.19c). A more contrasted image can be obtained by dividing the original image with its closing (Fig. 4.19d).
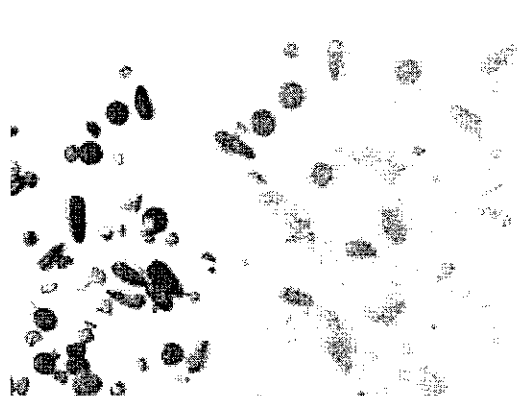

(a) Original image f (courtesy of Prof. B. Jähne, University of Heidelberg).
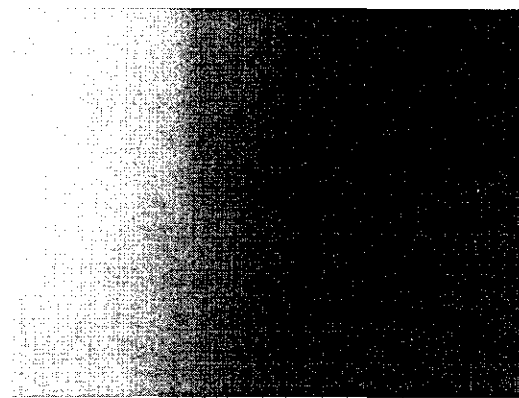
(b) Closing of f with a large square: $\phi(f)$
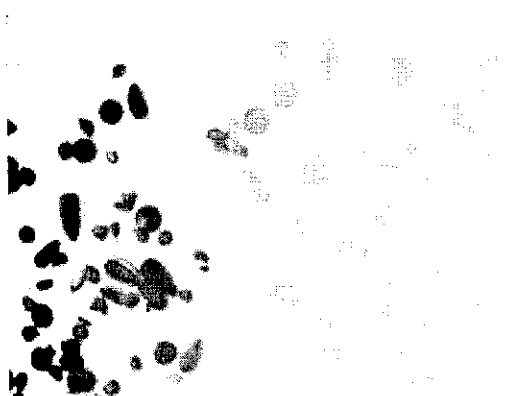
(c) Black top-hat: $\mathrm{BTH}(f) = \phi(f) - f$.

(d) Division of f by $\phi(f)$.

Fig. 4.19. Use of top-hat for mitigating inhomogeneous illumination. In this example, a better rendering is obtained by dividing the original image by the closed image.

Note that in quality control applications where a series of objects are acquired at a fixed position, another solution consists in first capturing an

with the degree of reduction being determined by the g y
surrounding the bright detail and by the shape and amplitude values of the
structuring element itself.

Gray-scale dilation and erosion are duals with respect to function comple-
mentation and reflection. That is,

$$(f \ominus b)^c(s, t) = (f^c \oplus \hat{b})(s, t) \qquad (9.6\text{-}3)$$

where $f^c = -f(x, y)$ and $\hat{b} = b(-x, -y)$. Except as needed for clarity, we simplify
the notation in the following discussions by omitting the arguments of all functions.

■ Figure 9.29(a) shows a simple 512×512 gray-scale image, and Fig. 9.29(b)
shows the result of dilating this image with a "flat-top" structuring element in the
shape of a parallelepiped of unit height and size 5×5 pixels. Based on the pre-
ceding discussion, dilation is expected to produce an image that is brighter than
the original and in which small, dark details have been reduced or eliminated.
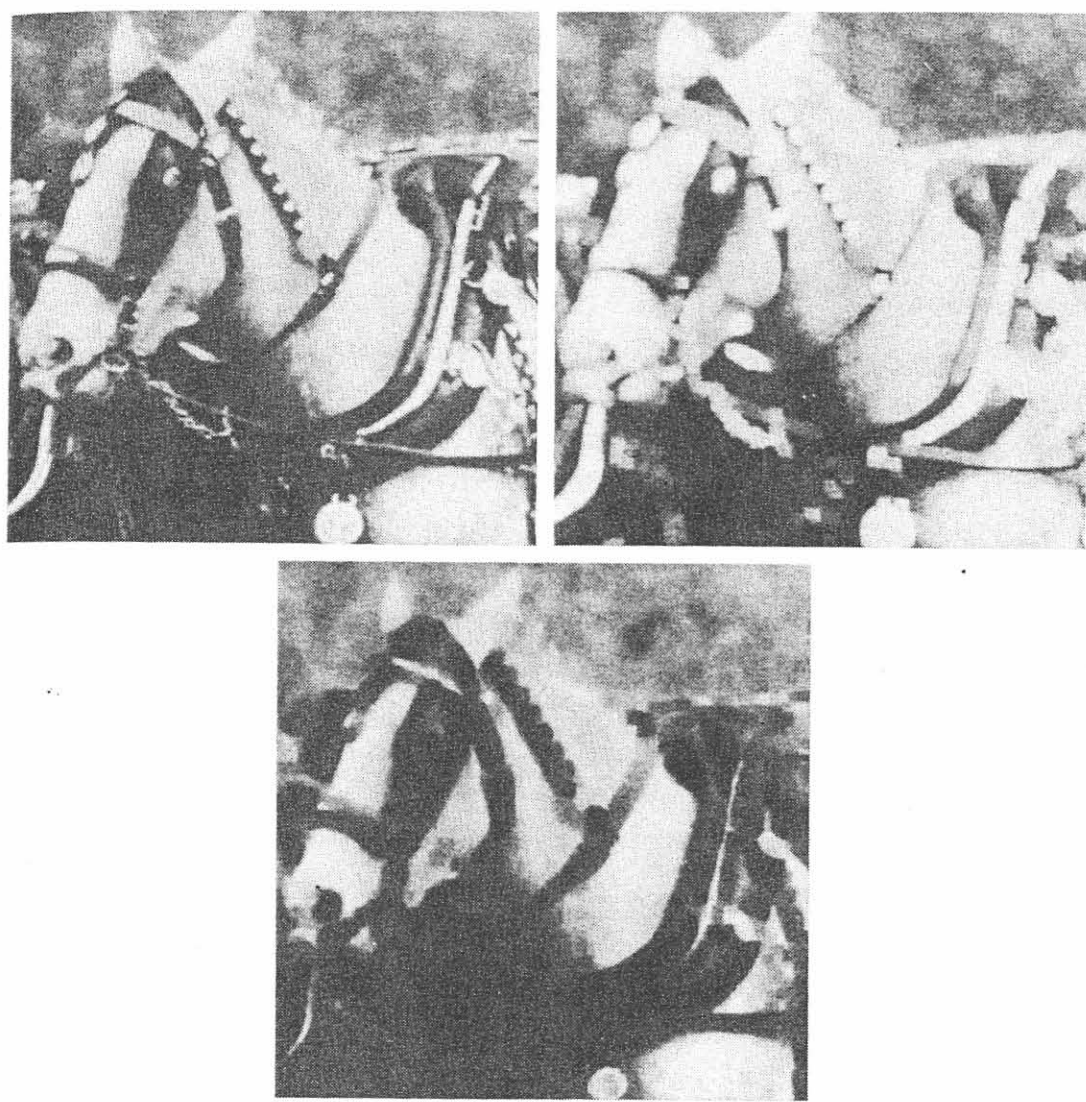
a b
c

FIGURE 9.29
(a) Original
image. (b) Resul
of dilation.
(c) Result of
erosion.
(Courtesy of
Mr. A. Morris,
Leica Cambridg
Ltd.)