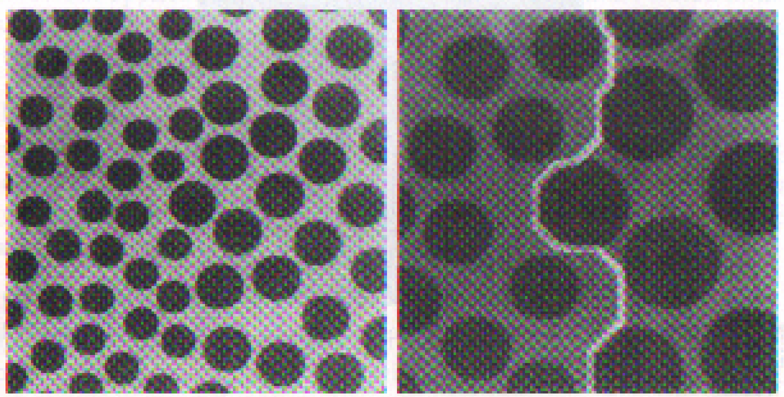
FIGURE 9.34 Result of performing a top-hat transformation on the image of Fig. 9.29(a). (Courtesy of Mr. A. Morris, Leica Cambridge, Ltd.)

where, as before, f is the input image and b is the structuring element function. This transformation—which owes its original name to the use of a cylindrical or parallelepiped structuring element function with a flat top—is useful for enhancing detail in the presence of shading. Figure 9.34 shows the result of performing a top-hat transformation on the image of Fig. 9.29(a). Note the enhancement of detail in the background region below the lower part of the horse's head.

Textural segmentation

Figure 9.35(a) shows a simple gray-scale image composed of two texture regions. The region on the right consists of circular blobs of larger diameter than those on the left. The objective is to find the boundary between the two regions based on their textural content.

Because closing tends to remove dark details from an image, the procedure in this particular case is to close the input image by using successively larger structuring elements. When the size of the structuring element corresponds to that of



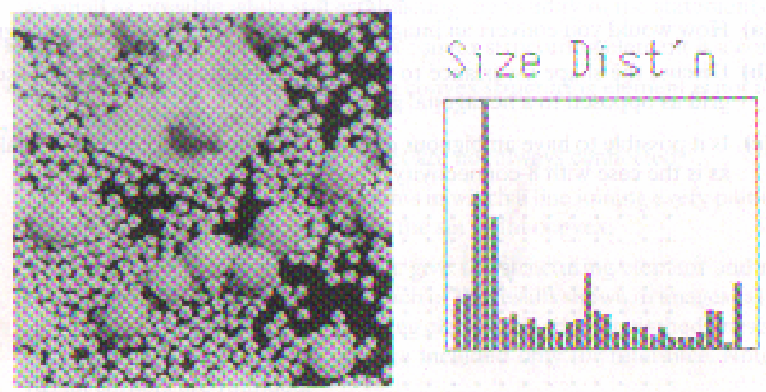
a b

FIGURE 9.35 (a) Original image. (b) Image showing boundary between regions of different texture. (Courtesy of Mr. A. Morris, Leica Cambridge, Ltd.)

the small blobs, they are removed from the image, leaving only a light background in the area previously occupied by them. At this point in the process, only the larger blobs and the light background on the left and between the large blobs themselves, remain. Next, a single opening is performed with a structuring element that is large in relation to the separation between the large blobs. This operation removes the light patches between the blobs, leaving a dark region on the right consisting of the large dark blobs and the now equally dark patches between these blobs. At this point the process has produced a light region on the left and a dark region on the right. A simple threshold then yields the boundary between the two textural regions. Figure 9.35(b) shows the resulting boundary superimposed on the original image. It is instructive to work through this example in more detail using the rolling ball analogy described in Fig. 9.30.

Granulometry

Granulometry is a field that deals principally with determining the size distribution of particles in an image. Figure 9.36(a) shows an image consisting of light objects of three different sizes. The objects not only are overlapping, but they also are too cluttered to enable detection of individual particles. Because the particles are lighter than the background, the following morphological approach can be used to determine size distribution. Opening operations with structuring elements of increasing size are performed on the original image. The difference between the original image and its opening is computed after each pass when a different structuring element is completed. At the end of the process, these differences are normalized and then used to construct a histogram of particle-size distribution. This approach is based on the idea that opening operations of a particular size have the most effect on regions of the input image that contain particles of similar size. Thus, a measure of the relative number of such particles is obtained by computing the difference between the input and output images. Figure 9.36(b) shows the resulting size distribution in this case. The histogram indicates the presence of three predominant particle sizes in the input image. This type of processing is useful for describing regions with a predominant particle-like character.



a b

FIGURE 9.36 (a) Original image consisting of overlapping particles; (b) size distribution. (Courtesy of Mr. A. Morris, Leica Cambridge, Ltd.)