第7章

计创18-8-连月菡

1.解释两个像素的距离.

一般地,对于某一集合S的元素p,q,r,把满足下述性质（称为距离的三公理）的函数d称为距离(distance)。

(1)只有当p=q时，才有d(p,q)=0;
(2)d(p,q)=d(q,p)
(3)d(p,r)<=d(p,q)+d(q,r)

(a)欧几里德距离

$$d_e((i,j),(h,k)) = \sqrt{(i-h)^2 + (j-k)^2}$$

(b)4-邻域距离

$$d_4((i,j),(h,k)) = |i-h| + |j-k|$$

(c)8-邻域距离

$$d_8((i,j),(h,k)) = \max\{|i-h|, |j-k|\}$$

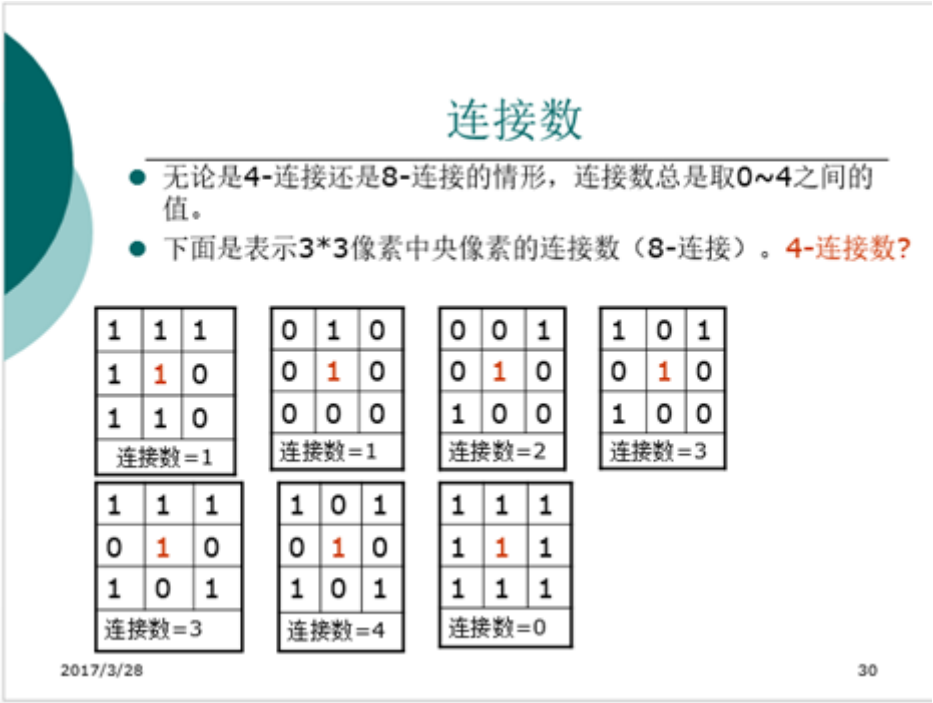
从一个像素开始的等距离线，在d_e中大致呈圆形，在d_4中旋转了45度的正方形，在d_8中呈正方形。

2.解释开和闭运算的用途.

开运算用途: 消除细小物体、在纤细点处分离物体和平滑较大物体的边界时不明显改变其面积。删除了不能包含结构元素的对象匹配；平滑对象的轮廓；断开狭窄的链接；消除细小的突出物。

开运算用途: 填充物体内细小空洞、连接临近物体、在不明显改变物体面积的情况下平滑其边界。

3.计算下图像素的4-连接数.



连接数:

1, 1,0,0,

1,0,0

4.翻译一段英文

第7章翻译作业 原文

Detecting a Cell Using Image Segmentation

用图像分割法探测一个细胞

An object can be easily detected in an image if the object has sufficient contrast from the background.

如果一个物体和背景的对比度充分, 那么这个物体很容易就被检测到

We use edge detection and basic morphology tools to detect a prostate cancer cell.

我们用边缘检测和基本形态学工具来探测一个前列腺癌细胞

Key concepts:

关键概念

Edge detection, structuring element, erosion, dilation, segmentation

边缘检测, 结构化元素, 腐蚀,扩张, 分割

Key functions： edge, strel, imdilate, imerode, imfill, imclearborder

关键功能: 边缘, 结构, 图像扩张, 图像腐蚀,图像边缘清晰化

Overview of Demo

样例概览

The demo includes these steps:

样例包含以下步骤:

Step 1: Read Image

第一步:读取图像

Step 2: Detect Entire Cell

第二步:探测整个细胞

Step 3: Fill Gaps

第三步:填补空隙

Step 4: Dilate the Image

第四步:扩张图像

Step 5: Fill Interior Gaps

第五步:填补内部空隙

Step 6: Remove Connected Objects on Border

第六步:移除边缘的连接像素

Step 7: Smooth the Object

第七步:平滑对象

Step 1: Read Image .Read in 'cell.tif', which is an image of a prostate cancer cell.

第一步:读取图像, "cell.tif"是前列腺癌细胞的图像。

```
I = imread('cell.tif');
figure, imshow(I), title('original image');
```

Step 2: Detect Entire Cell

Two cells are present in this image, but only one cell can be seen in its entirety. We will detect this cell. Another word for object detection is segmentation. The object to be segmented differs greatly in contrast from the background image. Changes in contrast can be detected by operators that calculate the gradient of an image. One way to calculate the gradient of an image is the Sobel operator, which creates a binary mask using a user-specified threshold value.We determine a threshold value using the graythresh function. To create the binary gradient mask, we use the edge function.

第二步:探测整个细胞

图中有两个细胞，但只有一个细胞是完整的。我们将探测这个细胞。换句话说, 目标检测就是图像分割。被分割的对象与背景图像形成了强烈的对比。对比度的变化可以被计算图像梯度的操作人员检测到。计算图像梯度的一种方法是使用Sobel运算符，它使用用户指定的阈值创建一个二进制掩码。我们使用graythresh函数确定阈值。要创建二元梯度掩码，我们使用edge函数

```
BWs = edge(I, 'sobel', (graythresh(I) \* .1));
figure, imshow(BWs), title('binary gradient mask');
```

Step 3: Fill Gaps

The binary gradient mask shows lines of high contrast in the image. These lines do not quite delineate the outline of the object of interest. Compared to the original image, you can see gaps in the lines surrounding the object in the gradient mask. These linear gaps will disappear if the Sobel image is dilated using linear structuring elements, which we can create with the strel function.

第三步:填补空隙

二元梯度掩膜显示图像中的高对比度线条。这些线条并不能很好地勾勒出感兴趣的物体的轮廓。与原始图像相比，你可以在渐变蒙版中看到物体周围线条的间隙。如果使用线性结构元素(我们可以使用strel函数创建)来扩展Sobel图像，这些线性间隙将会消失。

```
se90 = strel('line', 3, 90);
se0 = strel('line', 3, 0);
```

Step 4: Dilate the Image

The binary gradient mask is dilated using the vertical structuring element followed by the horizontal structuring element. The imdilate function dilates the image.

第四步:放大图片

该二元梯度掩码使用垂直结构元素和水平结构元素进行扩展。图像扩张功能使图像膨胀

```
BWsdil = imdilate(BWs, [se90 se0]);
figure, imshow(BWsdil), title('dilated gradient mask');
```

Step 5: Fill Interior Gaps

The dilated gradient mask shows the outline of the cell quite nicely, but there are still holes in the interior of the cell. To fill these holes we use the imfill function.

第五步:填补内部空隙

放大的渐变蒙版很好地显示了细胞的轮廓，但细胞内部仍然有空隙。为了填补这些洞，我们使用填充函数。

```
BWdfill = imfill(BWsdil, 'holes');
figure, imshow(BWdfill);
title('binary image with filled holes');
```

Step 6: Remove Connected Objects on Border

The cell of interest has been successfully segmented, but it is not the only object that has been found. Any objects that are connected to the border of the image can be removed using the imclearborder function. The connectivity in the imclearborder function was set to 4 to remove diagonal connections.

步骤6:移除边缘的连接像素

我们成功地分割了感兴趣的单元格，但它并不是发现的唯一对象。可以使用imclearborder函数删除连接到图像边界的任何对象。imclearborder函数中的连接性被设置为4以删除对角线连接。

```
BWnobord = imclearborder(BWdfill, 4);
figure, imshow(BWnobord), title('cleared border image');
```

Step 7: Smooth the Object

Finally, in order to make the segmented object look natural, we smooth the object by eroding the image twice with a diamond structuring element. We create the diamond structuring element using the strel function.

第七步:平滑对象

最后，为了使分割后的对象看起来更自然，我们使用菱形结构元素对图像进行两次腐蚀来平滑对象。我们使用strel函数创建菱形结构元素。

```
seD = strel('diamond',1);
BWfinal = imerode(BWnobord,seD);
BWfinal = imerode(BWfinal,seD);
figure, imshow(BWfinal), title('segmented image');
```

An alternate method for displaying the segmented object would be to place an outline around the segmented cell. The outline is created by the bwperim function.

显示分割后的对象的另一种方法是在被分割的细胞周围放置一个轮廓。轮廓是由bwperim函数创建的。

```
BWoutline = bwperim(BWfinal);
Segout = I;
Segout(BWoutline) = 255;
figure, imshow(Segout), title('outlined original image');
```

5.进行以下的运算：

Exercises

1. For each of the following images A and structuring elements B:

A =

0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0
0 0 0 1 1 1 1 0	0 1 1 1 1 1 1 0	0 0 0 0 0 1 1 0
0 0 0 1 1 1 1 0	0 1 1 1 1 1 1 0	0 1 1 1 0 1 1 0
0 1 1 1 1 1 1 0	0 1 1 0 0 1 1 0	0 1 1 1 0 1 1 0
0 1 1 1 1 1 1 0	0 1 1 0 0 1 1 0	0 1 1 1 0 1 1 0
0 1 1 1 1 0 0 0	0 1 1 1 1 1 1 0	0 1 1 1 0 0 0 0
0 1 1 1 1 0 0 0	0 1 1 1 1 1 1 0	0 1 1 1 0 0 0 0
0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0

B =

0 1 0	1 1 1	1 0 0
1 1 1	1 1 1	0 0 0
0 1 0	1 1 1	0 0 1

calculate the erosion A⊖B, the dilation $A \oplus B$, the opening $A \circ B$ and the closing $A \cdot B$.

---

(1)腐蚀运算

a1 =

0	0	0	0	0	0	0	0
0	0	0	1	1	1	1	0
0	0	0	1	1	1	1	0
0	1	1	1	1	1	1	0
0	1	1	1	1	1	1	0
0	1	1	1	1	0	0	0
0	1	1	1	1	0	0	0
0	0	0	0	0	0	0	0

b1 =

0	1	0
1	1	1
0	1	0

b2 =

1	1	1
1	1	1
1	1	1

b3 =

1	0	0
0	0	0
0	0	1

① a1⊖b1

```
>> A11=imerode(a1,b1)

A11 =

     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0
     0     0     0     0     1     1     0     0
     0     0     0     1     1     1     0     0
     0     0     1     1     1     0     0     0
     0     0     1     1     0     0     0     0
     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0
```

② a1⊖b2

```
>> A12=imerode(a1,b2)

A12 =

     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0
     0     0     0     0     1     1     0     0
     0     0     0     0     1     1     0     0
     0     0     1     1     0     0     0     0
     0     0     1     1     0     0     0     0
     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0
```

③ a1⊖b3

```
>> A13=imerode(a1,b3)

A13 =

     0     0     1     1     1     1     0   Inf
     0     0     0     0     0     0     0     0
     1     0     0     0     1     1     0     1
     1     0     0     0     1     1     0     1
     1     0     1     1     0     0     0     1
     1     0     1     1     0     0     0     1
     0     0     0     0     0     0     0     0
   Inf     0     1     1     1     1     0     0
```

(2)膨胀计算

① a1⊕b1

```
>> B11=imdilate(a1,b1)

B11 =

     0     0     0     1     1     1     1     0
     0     0     1     1     1     1     1     1
     0     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     0
     1     1     1     1     1     1     0     0
     0     1     1     1     1     0     0     0
```

② a1⊕b2

```
>> B12=imdilate(a1,b2)

B12 =

     0     0     1     1     1     1     1     1
     0     0     1     1     1     1     1     1
     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     0     0
     1     1     1     1     1     1     0     0
```

③ a1⊕b3

```
>> B13=imdilate(a1,b3)

B13 =

     0     0     1     1     1     1     0  -Inf
     0     0     1     1     1     1     0     0
     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1
     0     0     1     1     1     1     0     0
  -Inf     0     1     1     1     1     0     0
```

(3)开启运算

①.a1○b1

```
>> C11=imopen(a1,b1)

C11 =

     0     0     0     0     0     0     0     0
     0     0     0     0     1     1     0     0
     0     0     0     1     1     1     1     0
     0     0     1     1     1     1     1     0
     0     1     1     1     1     1     0     0
     0     1     1     1     1     0     0     0
     0     0     1     1     0     0     0     0
     0     0     0     0     0     0     0     0
```

② a1○b2

```
>> C12=imopen(a1,b2)

C12 =

     0     0     0     0     0     0     0     0
     0     0     0     1     1     1     1     0
     0     0     0     1     1     1     1     0
     0     1     1     1     1     1     1     0
     0     1     1     1     1     1     1     0
     0     1     1     1     1     0     0     0
     0     1     1     1     1     0     0     0
     0     0     0     0     0     0     0     0
```

③ a1○b3

```
>> C13=imopen(a1,b3)

C13 =

     0     0     0     0     0     0     0  -Inf
     0     0     0     1     1     1     1     0
     0     0     0     1     1     0     1     0
     0     1     1     0     0     1     1     0
     0     1     1     0     0     1     1     0
     0     1     0     1     1     0     0     0
     0     1     1     1     1     0     0     0
  -Inf     0     0     0     0     0     0     0
```

(4)闭合运算

① a1·b1

```
>> D11=imclose(a1,b1)

D11 =

     0     0     0     0     0     0     0     0
     0     0     0     1     1     1     1     0
     0     0     1     1     1     1     1     0
     0     1     1     1     1     1     1     0
     0     1     1     1     1     1     1     0
     0     1     1     1     1     1     0     0
     0     1     1     1     1     0     0     0
     0     0     0     0     0     0     0     0
```

② a1·b2

```
>> D12=imclose(a1,b2)

D12 =

     0     0     0     0     0     0     0     0
     0     0     0     1     1     1     1     0
     0     0     0     1     1     1     1     0
     0     1     1     1     1     1     1     0
     0     1     1     1     1     1     1     0
     0     1     1     1     1     0     0     0
     0     1     1     1     1     0     0     0
     0     0     0     0     0     0     0     0
```

③ a1·b3

```
>> D13=imclose(a1,b3)

D13 =

     0     0     0     0     0     0     0     0
     0     0     0     1     1     1     1     0
     0     0     0     1     1     1     1     0
     0     1     1     1     1     1     1     0
     0     1     1     1     1     1     1     0
     0     1     1     1     1     0     0     0
     0     1     1     1     1     0     0     0
     0     0     0     0     0     0     0     0
```

\2. a2与b1,b2,b3进行4种运算

(1).进行腐蚀运算

a2 =

0	0	0	0	0	0	0	0
0	1	1	1	1	1	1	0
0	1	1	1	1	1	1	0
0	1	1	0	0	1	1	0
0	1	1	0	0	1	1	0
0	1	1	1	1	1	1	0
0	1	1	1	1	1	1	0
0	0	0	0	0	0	0	0

b1 =

0	1	0
1	1	1
0	1	0

b2 =

1	1	1
1	1	1
1	1	1

b3 =

1	0	0
0	0	0
0	0	1

① a2⊖b1

```
>> A21=imerode(a2, b1)
```

A21 =

0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	1	0	0	1	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	1	0	0	1	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

② a2⊖b2

```
>> A22=imerode(a2, b2)

A22 =

     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0
```

③ a2⊖b3

```
>> A23=imerode(a2, b3)

A23 =

     1     1     1     1     1     1     0   Inf
     1     0     0     0     0     0     0     0
     1     0     0     0     1     1     0     1
     1     0     0     0     1     1     0     1
     1     0     1     1     0     0     0     1
     1     0     1     1     0     0     0     1
     0     0     0     0     0     0     0     1
   Inf     0     1     1     1     1     1     1
```

(2)进行膨胀计算

① a2⊕b1

```
>> B21=imdilate(a2,b1)

B21 =

     0     1     1     1     1     1     1     0
     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1
     0     1     1     1     1     1     1     0
```

② a2⊕b2

```
>> B22=imdilate(a2,b2)

B22 =

     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1
```

③ a2⊕b3

```
>> B23=imdilate(a2,b3)

B23 =

     1     1     1     1     1     1     0  -Inf
     1     1     1     1     1     1     0     0
     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1
     0     0     1     1     1     1     1     1
  -Inf     0     1     1     1     1     1     1
```

(3)进行开启运算

① a2○b1

```
>> C21=imopen(a2,b1)

C21 =

     0     0     0     0     0     0     0     0
     0     0     1     0     0     1     0     0
     0     1     1     1     1     1     1     0
     0     0     1     0     0     1     0     0
     0     0     1     0     0     1     0     0
     0     1     1     1     1     1     1     0
     0     0     1     0     0     1     0     0
     0     0     0     0     0     0     0     0
```

② a2○b2

```
>> C22=imopen(a2,b2)

C22 =

     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0
```

③ a2○b3

```
>> C23=imopen(a2,b3)

C23 =

     0     0     0     0     0     0     0  -Inf
     0     1     1     1     1     1     1     0
     0     1     0     1     1     0     1     0
     0     1     1     0     0     1     1     0
     0     1     1     0     0     1     1     0
     0     1     0     1     1     0     1     0
     0     1     1     1     1     1     1     0
  -Inf     0     0     0     0     0     0     0
```

(4)进行闭合运算

① a2·b1

```
>> D21=imclose(a2,b1)

D21 =

     0     0     0     0     0     0     0     0
     0     1     1     1     1     1     1     0
     0     1     1     1     1     1     1     0
     0     1     1     1     1     1     1     0
     0     1     1     1     1     1     1     0
     0     1     1     1     1     1     1     0
     0     1     1     1     1     1     1     0
     0     0     0     0     0     0     0     0
```

② a2·b2

```
>> D22=imclose(a2,b2)

D22 =

     0     0     0     0     0     0     0     0
     0     1     1     1     1     1     1     0
     0     1     1     1     1     1     1     0
     0     1     1     1     1     1     1     0
     0     1     1     1     1     1     1     0
     0     1     1     1     1     1     1     0
     0     1     1     1     1     1     1     0
     0     0     0     0     0     0     0     0
```

③ a2·b3

```
>> D23=imclose(a2,b3)

D23 =

     0     0     0     0     0     0     0     0
     0     1     1     1     1     1     1     0
     0     1     1     1     1     1     1     0
     0     1     1     1     1     1     1     0
     0     1     1     1     1     1     1     0
     0     1     1     1     1     1     1     0
     0     1     1     1     1     1     1     0
     0     0     0     0     0     0     0     0
```

\3. a3与b1,b2,b3进行4种运算

(1)腐蚀运算

```
a3 =

     0     0     0     0     0     0     0     0
     0     0     0     0     0     1     1     0
     0     1     1     1     0     1     1     0
     0     1     1     1     0     1     1     0
     0     1     1     1     0     1     1     0
     0     1     1     1     0     0     0     0
     0     1     1     1     0     0     0     0
     0     0     0     0     0     0     0     0
```

```
b1 =

     0     1     0
     1     1     1
     0     1     0
```

```
b2 =

     1     1     1
     1     1     1
     1     1     1
```

```
b3 =

     1     0     0
     0     0     0
     0     0     1
```

① a3⊖b1

```
>>  A31=imerode(a3, b1)

A31 =

     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0
     0     0     1     0     0     0     0     0
     0     0     1     0     0     0     0     0
     0     0     1     0     0     0     0     0
     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0
```

② a3⊖b2

```
>>  A32=imerode(a3, b2)

A32 =

     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0
     0     0     1     0     0     0     0     0
     0     0     1     0     0     0     0     0
     0     0     1     0     0     0     0     0
     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0
```

③ a3⊖b3

```
>> A33=imerode(a3,b3)

A33 =

     0     0     0     0     1     1     0   Inf
     1     0     0     0     0     0     0     0
     1     0     0     0     0     0     0     1
     1     0     1     0     1     0     0     1
     1     0     1     0     0     0     0     1
     1     0     1     0     0     0     0     1
     0     0     0     0     0     0     0     0
   Inf     0     1     1     1     0     0     0
```

(2)膨胀计算

① a3⊕b1

```
>> B31=imdilate(a3,b1)

B31 =

     0     0     0     0     0     1     1     0
     0     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     0
     1     1     1     1     1     0     0     0
     0     1     1     1     0     0     0     0
```

② a3⊕b2

```
>> B32=imdilate(a3,b2)

B32 =

     0     0     0     0     1     1     1     1
     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1
     1     1     1     1     1     1     1     1
     1     1     1     1     1     0     0     0
     1     1     1     1     1     0     0     0
```

③ a3⊕b3

```
>> B33=imdilate(a3,b3)

B33 =

     0     0     0     0     1     1     0  -Inf
     1     1     1     0     1     1     0     0
     1     1     1     0     1     1     1     1
     1     1     1     1     1     1     1     1
     1     1     1     1     1     0     1     1
     1     1     1     1     1     0     1     1
     0     0     1     1     1     0     0     0
  -Inf     0     1     1     1     0     0     0
```

(3)开启运算

① a3○b1

```
>> C31=imopen(a3, b1)

C31 =

     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0
     0     0     1     0     0     0     0     0
     0     1     1     1     0     0     0     0
     0     1     1     1     0     0     0     0
     0     1     1     1     0     0     0     0
     0     0     1     0     0     0     0     0
     0     0     0     0     0     0     0     0
```

② a3○b2

```
>> C32=imopen(a3, b2)

C32 =

     0     0     0     0     0     0     0     0
     0     0     0     0     0     0     0     0
     0     1     1     1     0     0     0     0
     0     1     1     1     0     0     0     0
     0     1     1     1     0     0     0     0
     0     1     1     1     0     0     0     0
     0     1     1     1     0     0     0     0
     0     0     0     0     0     0     0     0
```

③ a3○b3

```
>> C33=imopen(a3, b3)

C33 =

     0     0     0     0     0     0     0  -Inf
     0     0     0     0     0     1     1     0
     0     1     0     1     0     0     1     0
     0     1     0     0     0     0     1     0
     0     1     0     1     0     1     1     0
     0     1     0     1     0     0     0     0
     0     1     1     1     0     0     0     0
  -Inf     0     0     0     0     0     0     0
```

(4)闭合运算

① a3·b1

```
>> D31=imclose(a3, b1)

D31 =

     0     0     0     0     0     0     0     0
     0     0     0     0     0     1     1     0
     0     1     1     1     1     1     1     0
     0     1     1     1     1     1     1     0
     0     1     1     1     1     1     1     0
     0     1     1     1     1     0     0     0
     0     1     1     1     0     0     0     0
     0     0     0     0     0     0     0     0
```

② a3·b2

```
>> D32=imclose(a3,b2)

D32 =

     0     0     0     0     0     0     0     0
     0     0     0     0     0     1     1     0
     0     1     1     1     1     1     1     0
     0     1     1     1     1     1     1     0
     0     1     1     1     1     1     1     0
     0     1     1     1     0     0     0     0
     0     1     1     1     0     0     0     0
     0     0     0     0     0     0     0     0
```

③ a3·b3

```
>> D33=imclose(a3,b3)

D33 =

     0     0     0     0     0     0     0     0
     0     0     0     0     0     1     1     0
     0     1     1     1     0     1     1     0
     0     1     1     1     0     1     1     0
     0     1     1     1     0     1     1     0
     0     1     1     1     0     0     0     0
     0     1     1     1     0     0     0     0
     0     0     0     0     0     0     0     0
```

6.查找资料了解“顶帽变换（top-hat）”。简要说明顶帽变换的基本思想及应用。

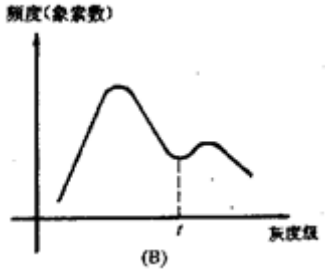
查找资料了解“黑帽变换（black-hat）”。简要说明黑帽变换的基本思想及应用。

用一个结构元通过开操作或闭操作从一副图像中删除物体，而不是拟合被删除的物体。然后，差操作得到一副仅保留已删除分量的图像。顶帽变换用于暗背景上的亮物体。

黑帽（Black Hat）运算为”闭运算“的结果图与原图像之差。黑帽运算后的效果图突出了比原图轮廓周围的区域更暗的区域，且这一操作和选择的核的大小相关。所以，黑帽运算用来分离比邻近点暗一些的斑块。

7.用C++编程实现：

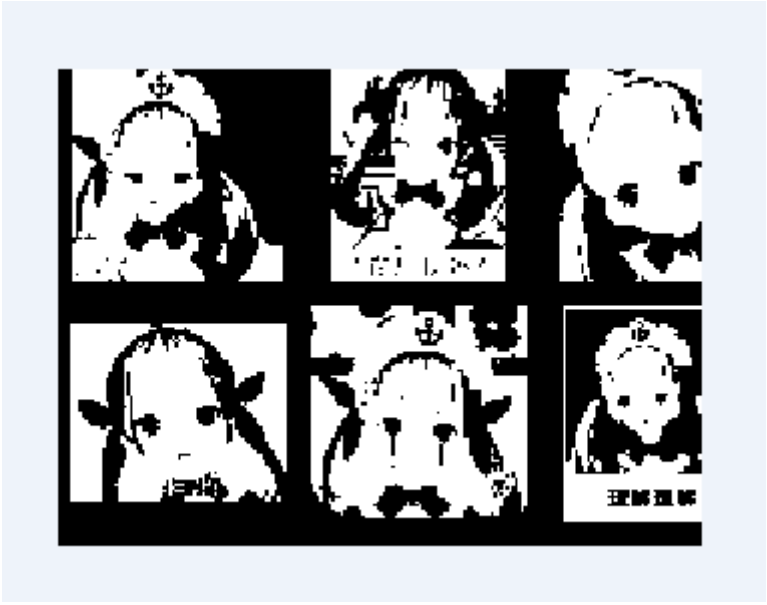
在8位灰度图像中求直方图，选择直方图的谷底作为阈值进行图像的二值化。如下图。
用多幅图像实验，讨论阈值选择是否合理。
扩展（自学）：查找资料研究利用直方图进行阈值计算有哪些方法。



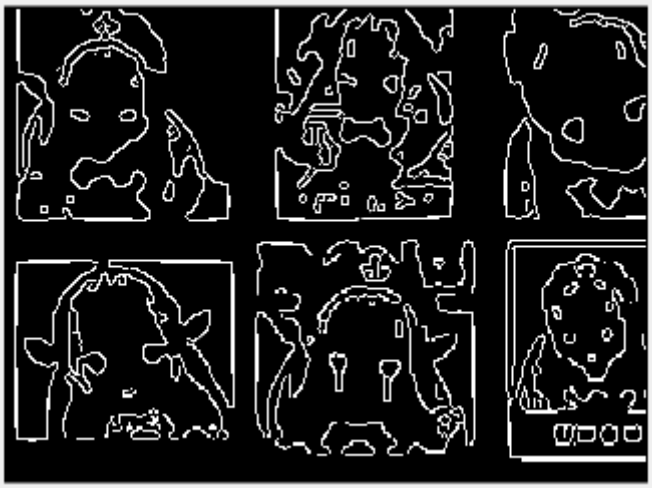
8.用Matlab编程实现：

在8位二值图像中用形态学的方法提取物体的内边界和外边界。结构元素的选择自己定义。
用多幅图像实验，讨论边界提取是否合理。

原图:

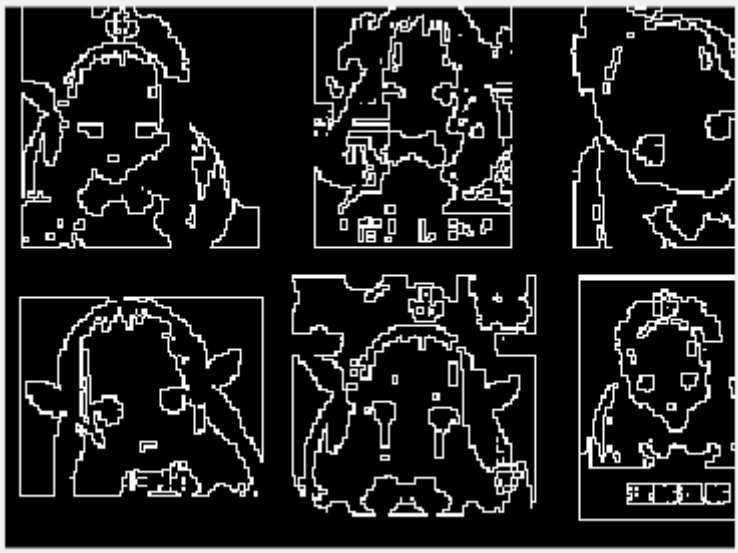


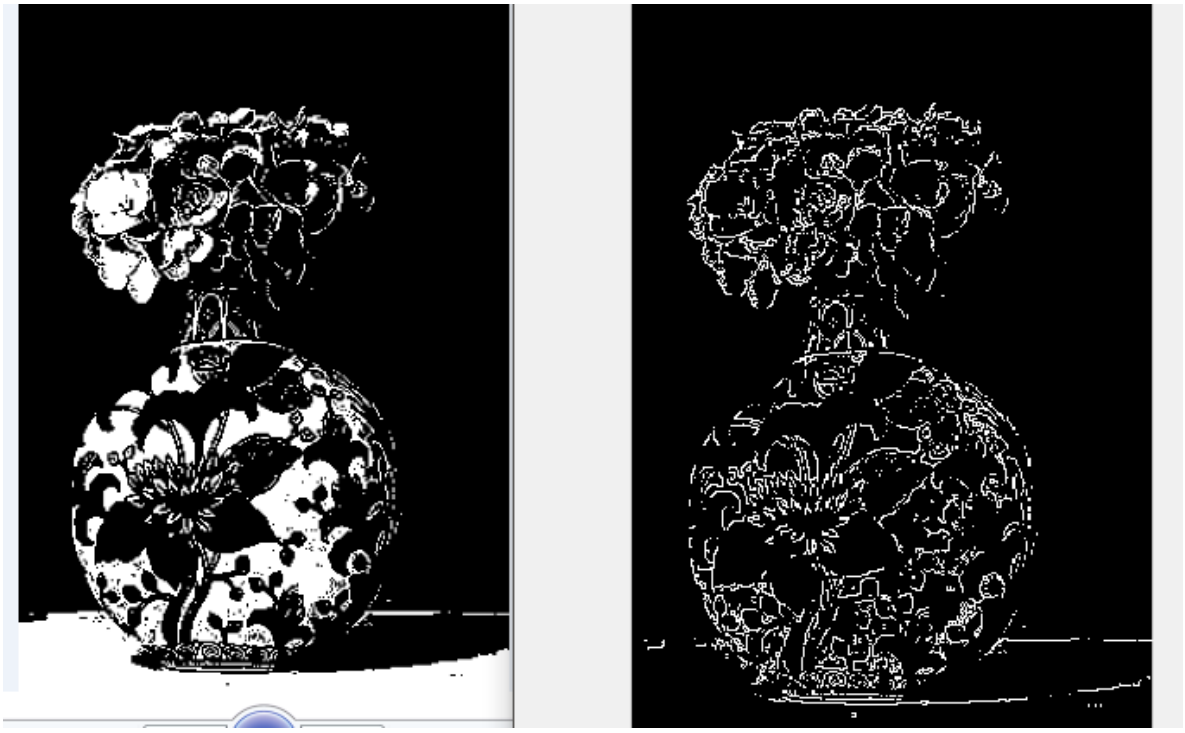
边界检测： Boundary Detection
(i) internal boundary $A-(A\Theta B)$



(ii) external boundary$(A \bigoplus B) - A$

```
I=im2double(imread('C:\Users\yuehan lian\Desktop\11.tif'));
%获得图像大小
[M,N]=size(I);
%存放膨胀后的图像
J=zeros(M,N);
%==============================边界提取==================================
%结构元素
n=3;
B=ones(n,n);
n_B=length(find(B==1));
%这里需要B对其原点进行翻转，因为B是对称的，所以翻转后的结果与其本身相同
l_m=floor(n/2);
l_n=floor(n/2);
%腐蚀操作
I_pad=padarray(I,[l_m,l_n],'symmetric');
for x=1:M
    for y=1:N
        %从扩展图像中取出子图像
         Block=I_pad(x:x+2*l_m,y:y+2*l_n);
         %将结构元素与子图像点乘,即逻辑“与”操作
         c=B.*Block;
         ind=find(c==1);
         if length(ind)==n_B
             J(x,y)=1;
         end
    end
end
Beta=I-J;
imshow(Beta,[]);
```





我认为比较合理。但是仍有一些不完美的噪点。