Mathematical Morphology - Grayscale morphological reconstruction

Assignment 5

Nom :
Prénom :

Grayscale images can be thought of in three dimensions: the x- and y-axes represent pixel positions and the z-axis represents the intensity of each pixel. In this interpretation, the intensity values represent elevations, as in a topographical map. The areas of high intensity and low intensity in an image, peaks and valleys in topographical terms, can be important morphological features because they often mark relevant image objects.

Contents

1. Finding peaks and valleys

```
clear all;
close all;

% The following simple image contains two primary regional maxima,
% the blocks of pixels containing the value 13 and 18, and several smaller maxima,
% set to 11.

A= [10 10 10 10 10 10 10 10 10 10
    10 13 13 13 10 10 11 10 11 10
    10 13 13 13 10 10 10 11 10 10
    10 13 13 13 10 10 11 10 11 10
    10 10 10 10 10 10 10 10 10 10
    10 11 10 10 10 18 18 18 10 10
    10 10 10 11 10 18 18 18 10 10
    10 10 11 10 10 18 18 18 10 10
    10 11 10 11 10 10 10 10 10 10
    10 10 10 11 10 10 11 10 10 10] ;
figure(1)
imagesc(A), colormap(gray);
```

1.1. Extract all regional maxima using imregionalmax

```
figure(2)
RegMax=imregionalmax(A);
imagesc(RegMax), colormap(gray);
```

Comment:

What is the type of the result image ?

Answer:

On obtient une image binaire avec plusieurs max régionaux. On n'a plus d'information sur l'amplitude des max régionaux

1.2. Extended regional maxima

You might want only to identify areas of the image where the change in intensity is extreme; that is, the difference between the pixel and neighboring pixels is greater than (or less than) a certain threshold. For example, to find only those regional maxima in the sample image, A, that are at least two units higher than their neighbors, use imextendedmax.

1.2.a) What is the difference between the two functions imregionalmax and imextendedmax?

Answer: parameter h of contrast

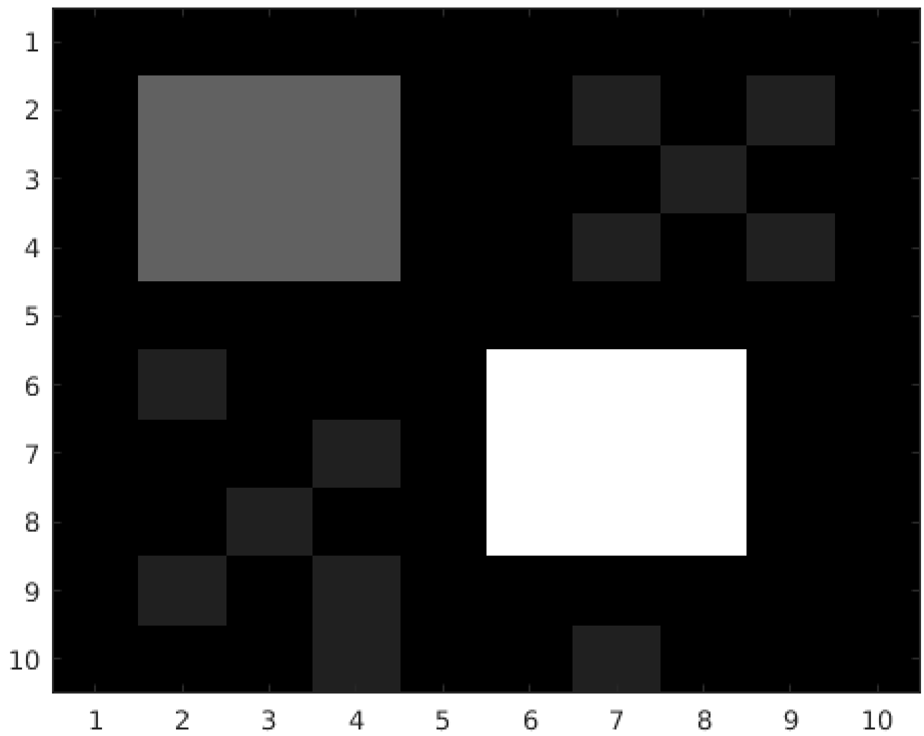
1.2.b)

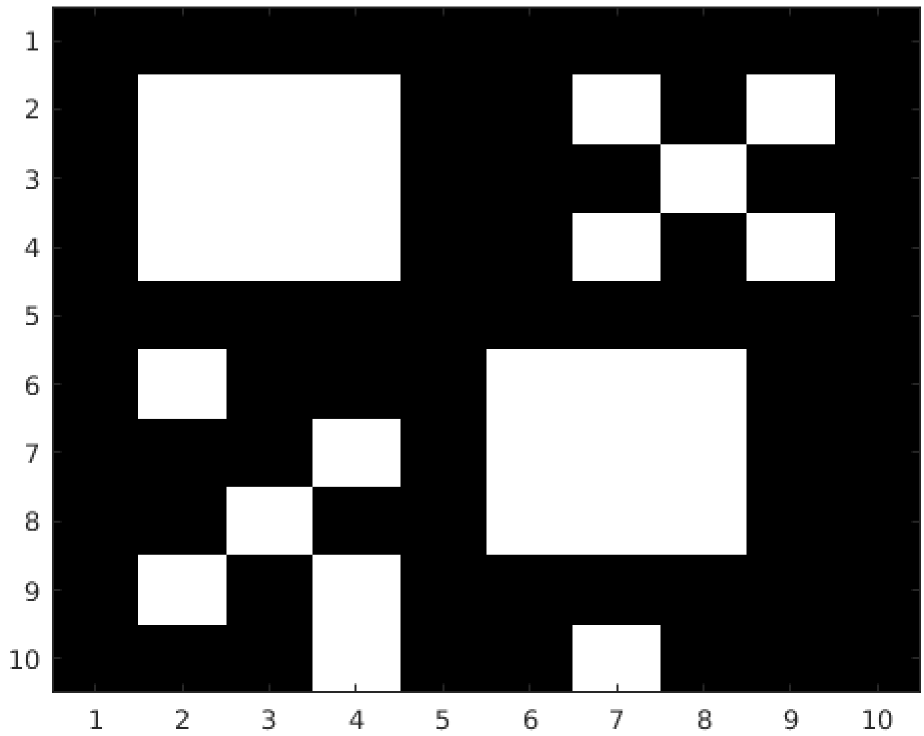
```
%Code:
figure(3)
MaxEtendus = imextendedmax(A,2);
imagesc(MaxEtendus), colormap(gray)
```

1.2.c)

Comment (+ comparison with the previous result)

Answer : on n'a plus que 2 maxima. Les autres ont été filtrés en fonction du contraste.


1
2
3
4
5
6
7
8
9
10
1
2
3
4
5
6
7
8
9
10


1
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1
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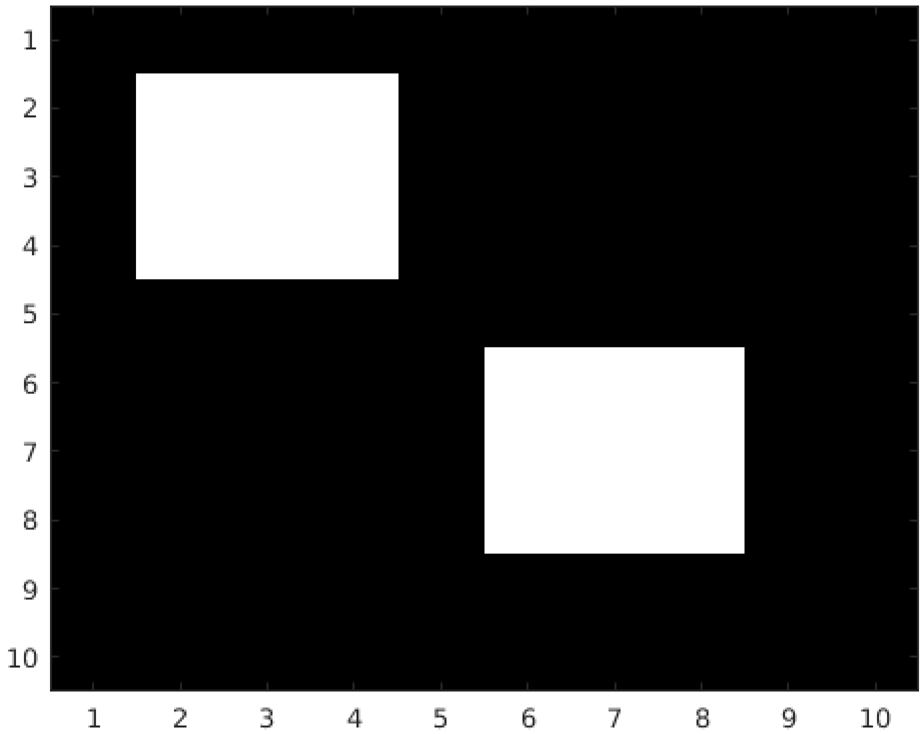
5
6
7
8
9
10



2. Suppressing Minima and Maxima

In an image, every small fluctuation in intensity represents a regional minimum or maximum. You might only be interested in significant minima or maxima and not in these smaller minima and maxima caused by background texture.

To remove the less significant minima and maxima but retain the significant minima and maxima, use the imhmax or imhmin function. With these functions, you can specify a contrast criteria or threshold level, h, that suppresses all maxima whose height is less than h or whose minima are greater than h.

2.1. hmin and hmax

Which type of image is returned with imhmin or imhmax? (BW, grey, color, ..) ?

Important note : The imregionalmin, imregionalmax, imextendedmin, and imextendedmax functions return a binary image that marks the locations of the regional minima and maxima in an image. The imhmax and imhmin functions produce an altered image.

The simple image B contains two primary regional maxima, the blocks of pixels containing the value 14 and 18, and several smaller maxima, set to 11.

```
B= [10 10 10 10 10 10 10 10 10 10
    10 14 14 14 10 10 11 10 11 10
    10 14 14 14 10 10 10 11 10 10
    10 14 14 14 10 10 11 10 11 10
    10 10 10 10 10 10 10 10 10 10
```

```
    10 11 10 10 10 18 18 18 10 10
    10 10 10 11 10 18 18 18 10 10
    10 10 11 10 10 18 18 18 10 10
    10 11 10 11 10 10 10 10 10 10
    10 10 10 11 10 10 11 10 10 10] ;
```

2.2.

By using imhmax, eliminate all regional maxima except the two significant maxima (with values 14 and 18). Compare the values of the resulting matrix with the original matrix B.

2.2.a)

```
% Code:

figure(4)
imagesc(B), colormap(gray)
B1=imhmax(B,2)
figure(5)
imagesc(B1), colormap(gray);

B2= B - B1
figure(6);
imagesc(B2), colormap(gray);
```

2.2.b)

Comment :

Specifying a threshold value of 2. Note that imhmax only affects the maxima; none of the other pixel values are changed. The two significant maxima remain, although their heights are reduced.

2.3

The simple image C contains two primary regional maxima, the blocks of pixels containing the values 14 and 18, and several smaller maxima, set to 11. One pixel of the regional maximum of value 14 is corrupted by noise and set to 1.

```
C= [10 10 10 10 10 10 10 10 10 10
    10 14 14 14 10 10 11 10 11 10
    10 20 14 14 10 10 10 11 10 10
    10 14 14 14 10 10 11 10 11 10
    10 10 10 10 10 10 10 10 10 10
    10 11 10 10 10 18 18 18 10 10
    10 10 10 11 10 18 18 18 10 10
    10 10 11 10 10 18 18 18 10 10
    10 11 10 11 10 10 10 10 10 10
    10 10 10 11 10 10 11 10 10 10] ;
```

Eliminate all regional maxima except the two significant maxima (with values 14 and 18), removing the noise. Compare the values of the result matrix with the original matrix C.

2.3.a)

```
% Code:

figure(7)
imagesc(C), colormap(gray);

C1=imhmax(C,6)
figure(8)
imagesc(C1), colormap(gray);

C2= C - C1
figure(9)
imagesc(C2), colormap(gray);
```

2.3.b)

Comment:

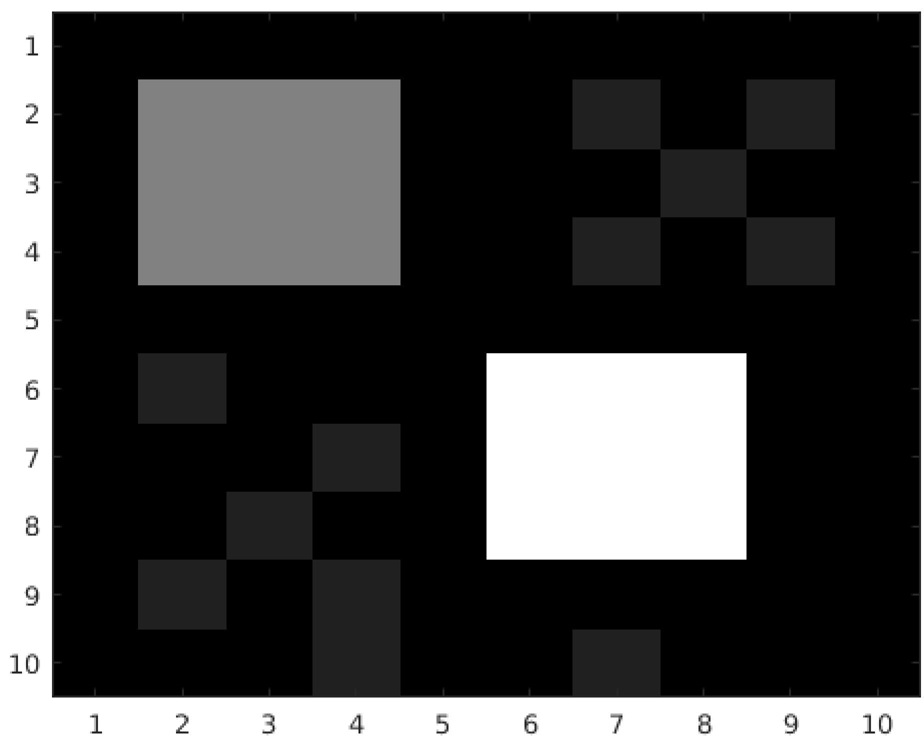
Il faut choisir la valeur 6 car cela permet de corriger le pic de bruit, de ramener la valeur du pixel 20 à 14, sans supprimer l'autre maximum régional. Par contre, celui-ci est atténué.

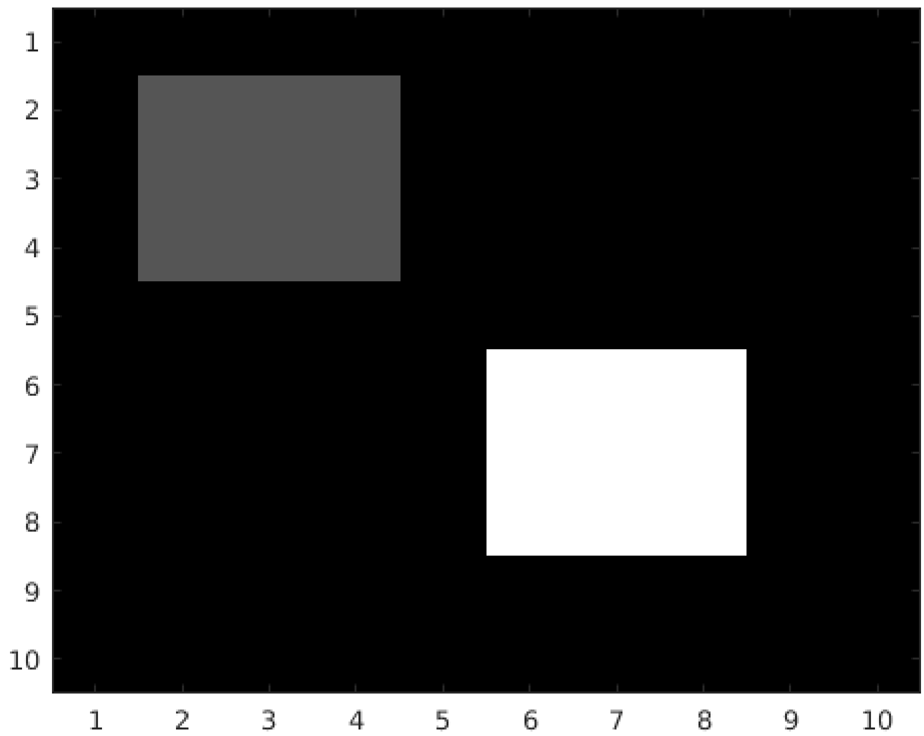
```
B1 =

    10    10    10    10    10    10    10    10    10    10
    10    12    12    12    10    10    10    10    10    10
    10    12    12    12    10    10    10    10    10    10
    10    12    12    12    10    10    10    10    10    10
    10    10    10    10    10    10    10    10    10    10
    10    10    10    10    10    16    16    16    10    10
    10    10    10    10    10    16    16    16    10    10
    10    10    10    10    10    16    16    16    10    10
    10    10    10    10    10    10    10    10    10    10
    10    10    10    10    10    10    10    10    10    10


B2 =

     0     0     0     0     0     0     0     0     0     0
     0     2     2     2     0     0     1     0     1     0
     0     2     2     2     0     0     0     1     0     0
     0     2     2     2     0     0     1     0     1     0
     0     0     0     0     0     0     0     0     0     0
     0     1     0     0     0     2     2     2     0     0
     0     0     0     1     0     2     2     2     0     0
     0     0     1     0     0     2     2     2     0     0
     0     1     0     1     0     0     0     0     0     0
     0     0     0     1     0     0     1     0     0     0


C1 =
```

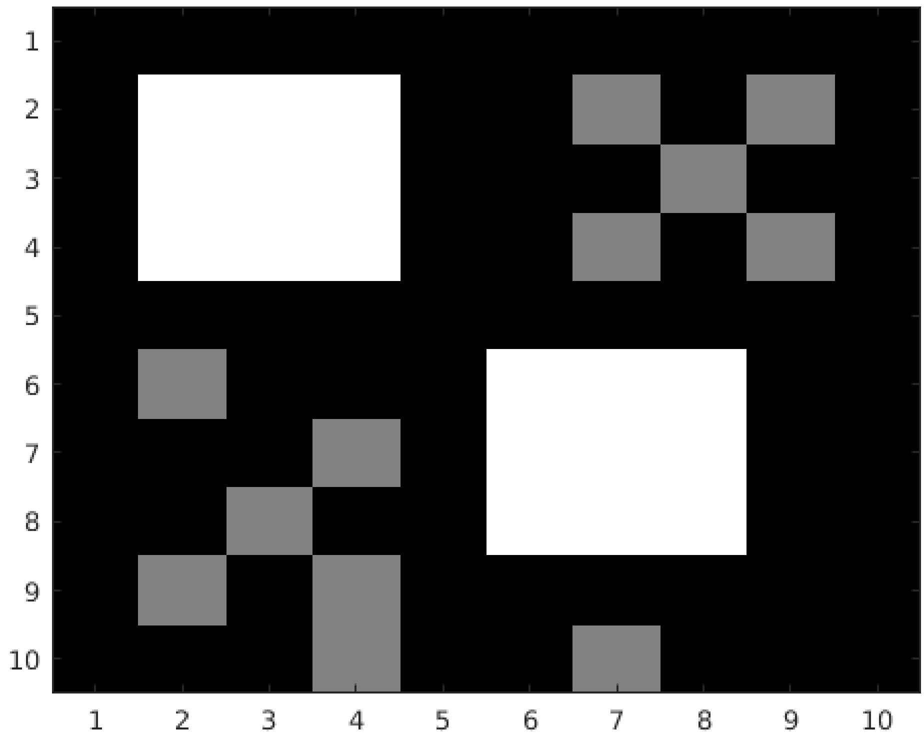
10	10	10	10	10	10	10	10	10	10
10	14	14	14	10	10	10	10	10	10
10	14	14	14	10	10	10	10	10	10
10	14	14	14	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	12	12	12	10	10
10	10	10	10	10	12	12	12	10	10
10	10	10	10	10	12	12	12	10	10
10	10	10	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	10

```
C2 =
```

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	1	0	1	0
0	6	0	0	0	0	0	1	0	0
0	0	0	0	0	0	1	0	1	0
0	0	0	0	0	0	0	0	0	0
0	1	0	0	0	6	6	6	0	0
0	0	0	1	0	6	6	6	0	0
0	0	1	0	0	6	6	6	0	0
0	1	0	1	0	0	0	0	0	0
0	0	0	1	0	0	1	0	0	0




1
2
3
4
5
6
7
8
9
10
1 2 3 4 5 6 7 8 9 10


1
2
3
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5
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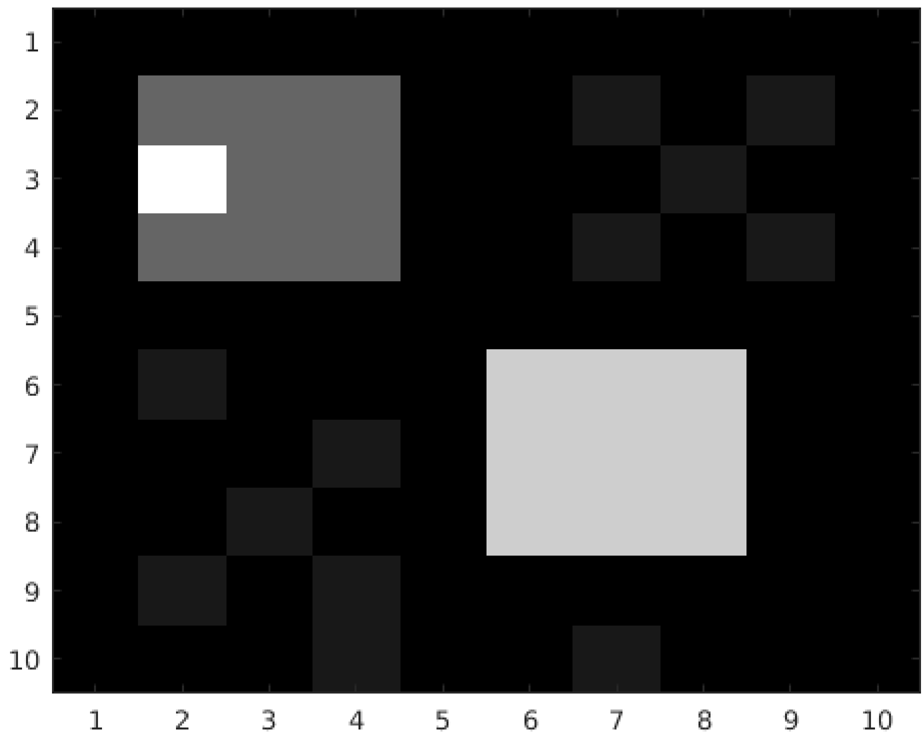
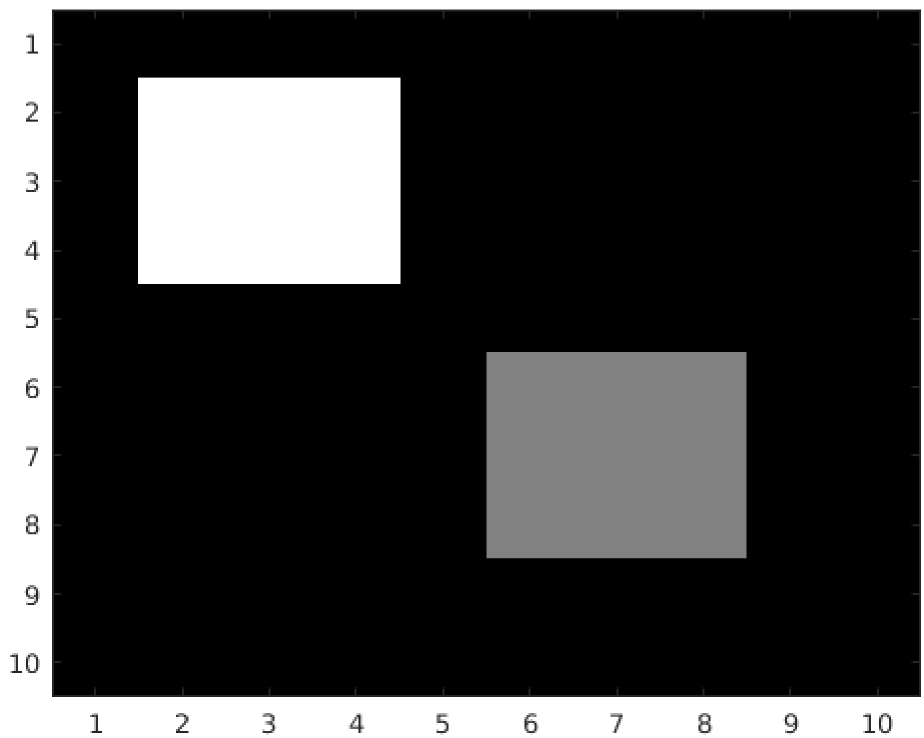
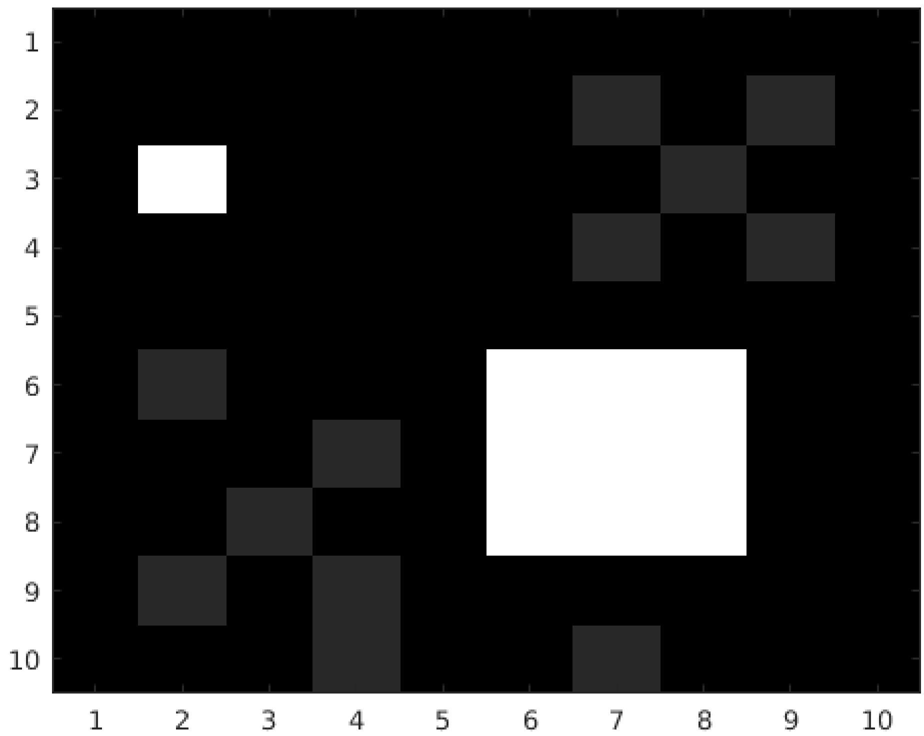
7
8
9
10
1 2 3 4 5 6 7 8 9 10


1
2
3
4
5
6
7
8
9
10
1 2 3 4 5 6 7 8 9 10


1
2
3
4
5
6
7
8
9
10
1 2 3 4 5 6 7 8 9 10



2.4

The simple image D contains two primary regional minima, the blocks of pixels containing the value 14 and 18, and several deeper minima, set to 11.

```
D= [24 24 24 24 24 24 24 24 24 24
    24 14 14 14 24 24 11 24 11 24
    24 14 14 14 24 24 24 11 24 24
    24 14 14 14 24 24 11 24 11 24
    24 24 24 24 24 24 24 24 24 24
    24 11 24 24 24 18 18 18 24 24
    24 24 24 11 24 18 18 18 24 24
    24 24 11 24 24 18 18 18 24 24
    24 11 24 11 24 24 24 24 24 24
    24 24 24 11 24 24 11 24 24 24] ;
```

Eliminate all regional minima except the minima equal to 11,

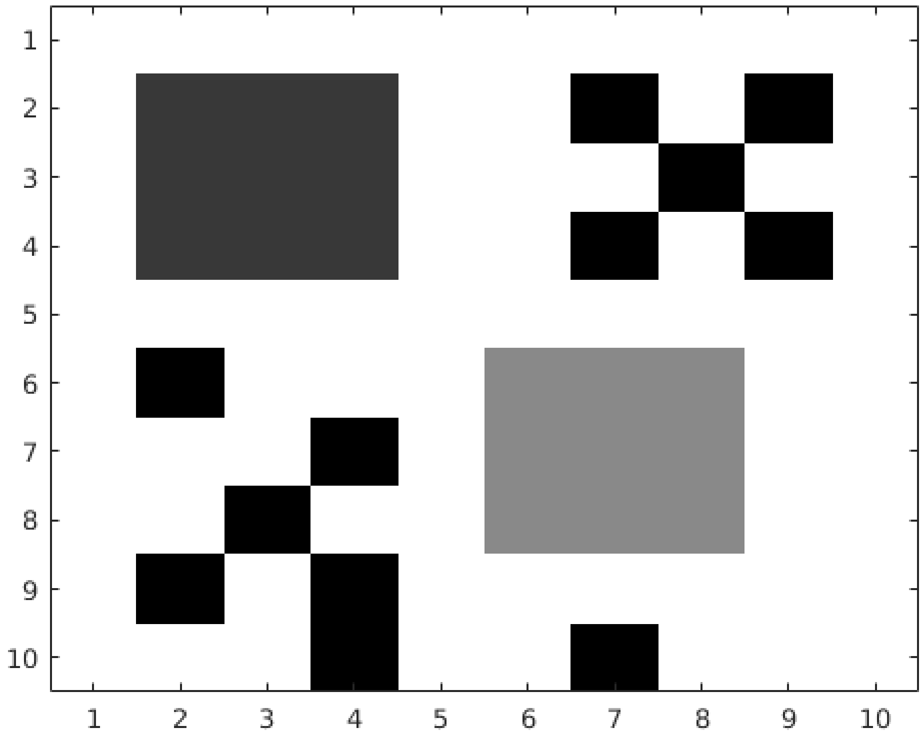
2.4.a)

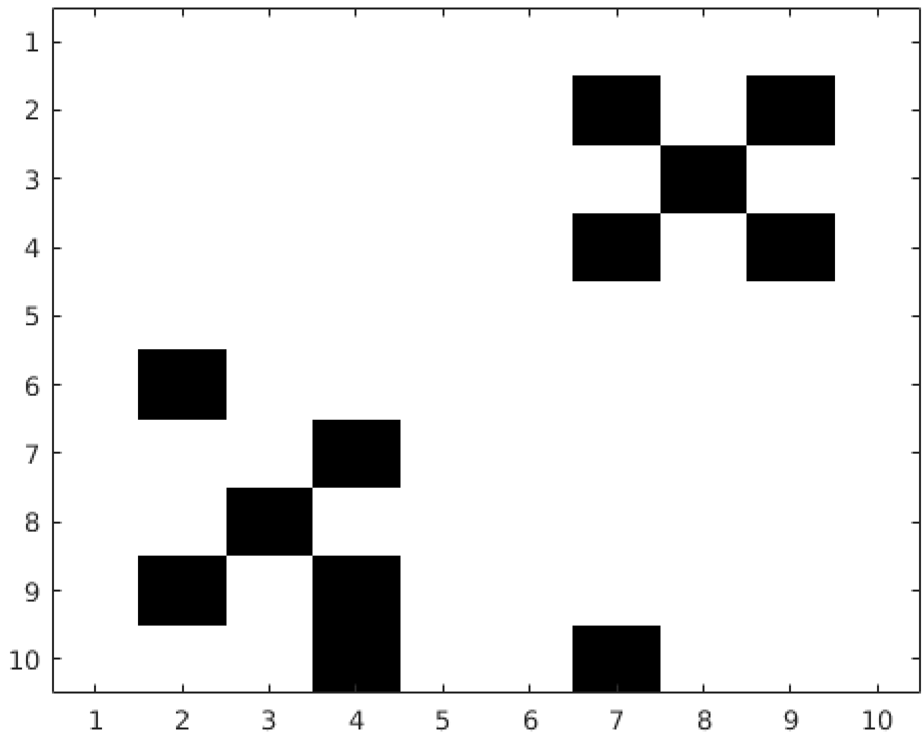
```
% Code:

figure(10)
imagesc(D), colormap(gray)

D2=imhmin(D,10) ; % avec 6, on supprime le min à 18, avec 10, on supprime le min de
figure(11)
imagesc(D2), colormap(gray)
```

2.4.b)

Comment:

On réhausse cette fois les creux. avec 6, on supprime le min à 18, avec 10, on supprime le min de 14.





2.5

The simple image E contains one primary regional minima with a noisy pixel set to 12 instead of 14.

```
E= [24 24 24 24 24
    24 14 14 14 24
    24 14 14 14 24
    24 14 12 14 24
    24 24 24 24 24
    24 24 24 24 24 ] ;
```

Eliminate the noisy pixel, varying the parameter h between 1, 2, 3 and 4. Check the resulting values for each h parameter.

2.5.a)

```
% Code:

figure(12)
imagesc(E), colormap(gray)
E2=imhmin(E,1)
figure(13)
imagesc(E2), colormap(gray)

E2=imhmin(E,2)
figure(14)
imagesc(E2), colormap(gray)
```

```
E2=imhmin(E,3)
figure(15)
imagesc(E2), colormap(gray)

E2=imhmin(E,4)
figure(16)
imagesc(E2), colormap(gray)
```

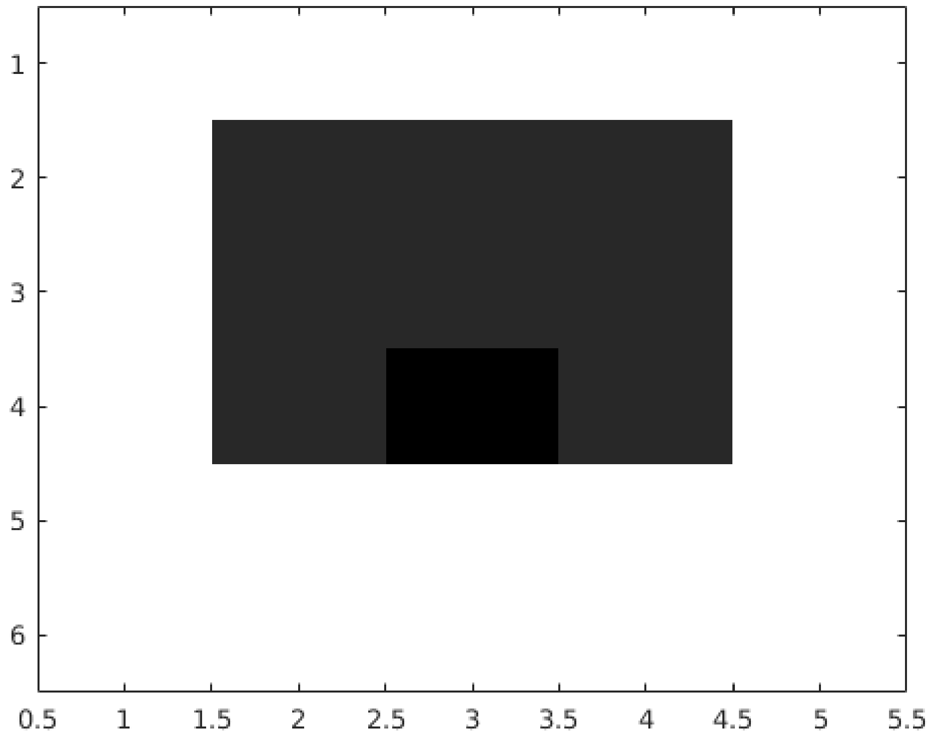
2.5.b)

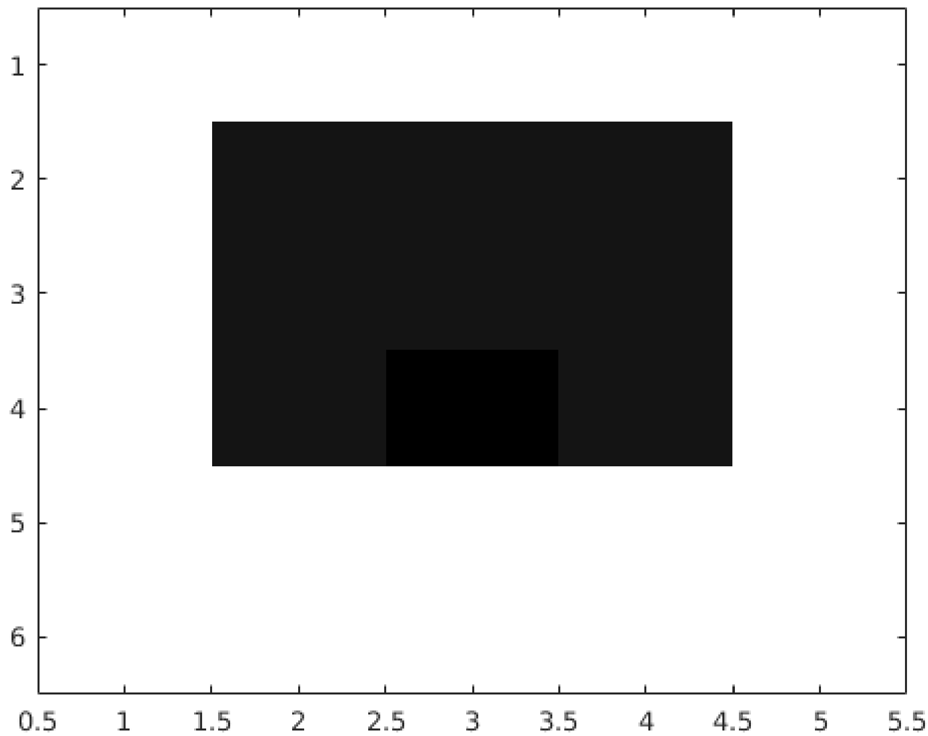
Comment:

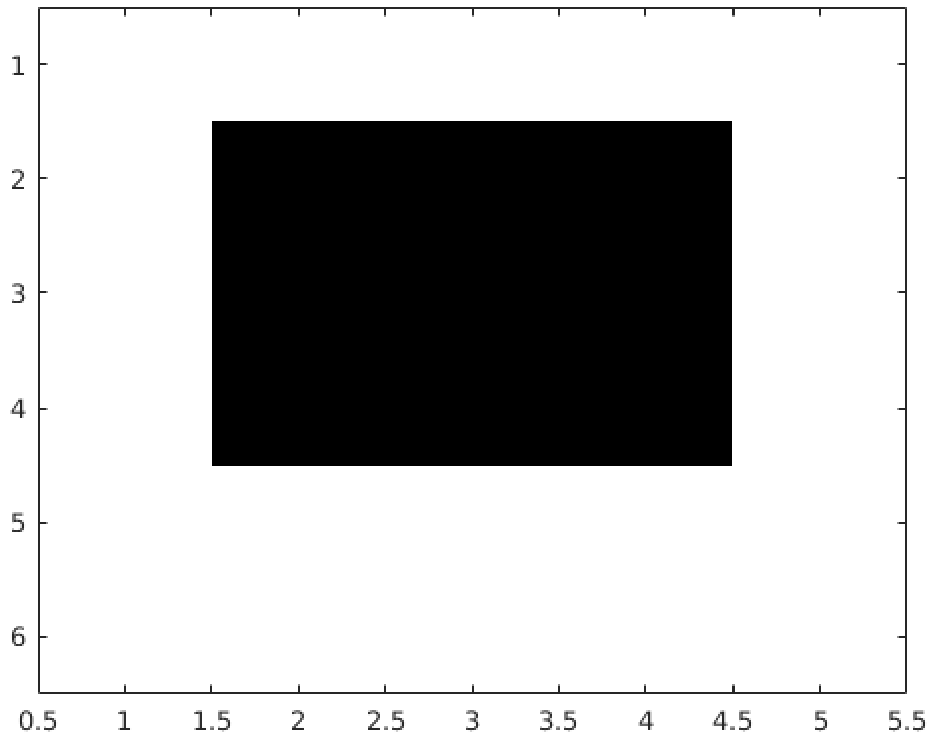
On réhausse cette fois les creux. On part bien du point le plus bas de la vallée, et on réhausse les valeurs du creux progressivement.

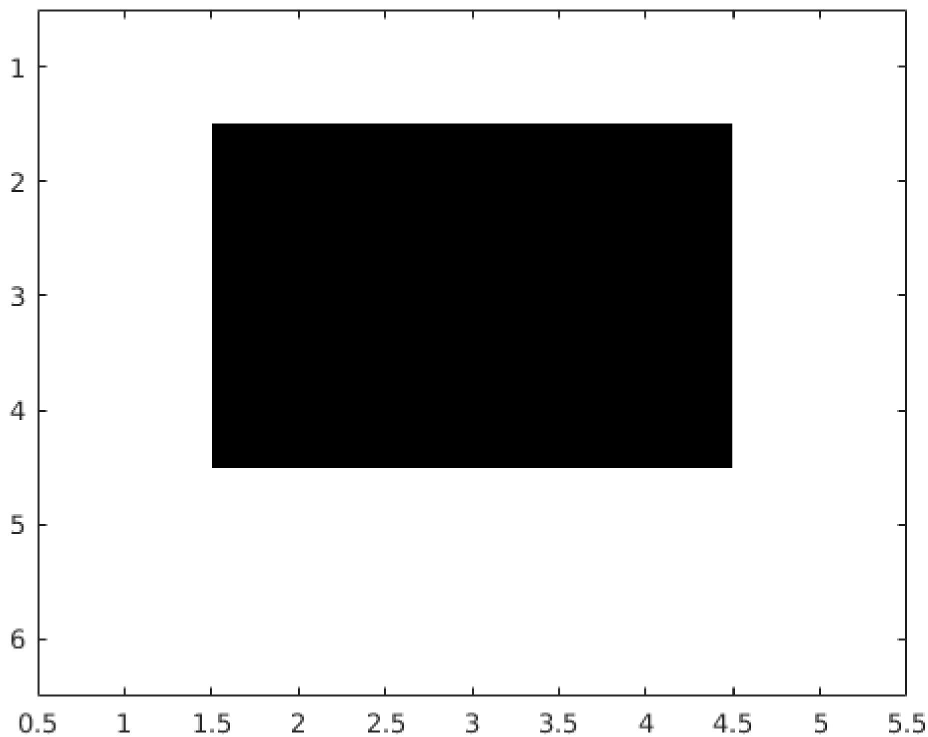
```
E2 =

    24    24    24    24    24
    24    14    14    14    24
    24    14    14    14    24
    24    14    13    14    24
    24    24    24    24    24
    24    24    24    24    24


E2 =

    24    24    24    24    24
    24    14    14    14    24
    24    14    14    14    24
    24    14    14    14    24
    24    24    24    24    24
    24    24    24    24    24


E2 =

    24    24    24    24    24
    24    15    15    15    24
    24    15    15    15    24
    24    15    15    15    24
    24    24    24    24    24
    24    24    24    24    24


E2 =

    24    24    24    24    24
    24    16    16    16    24
```

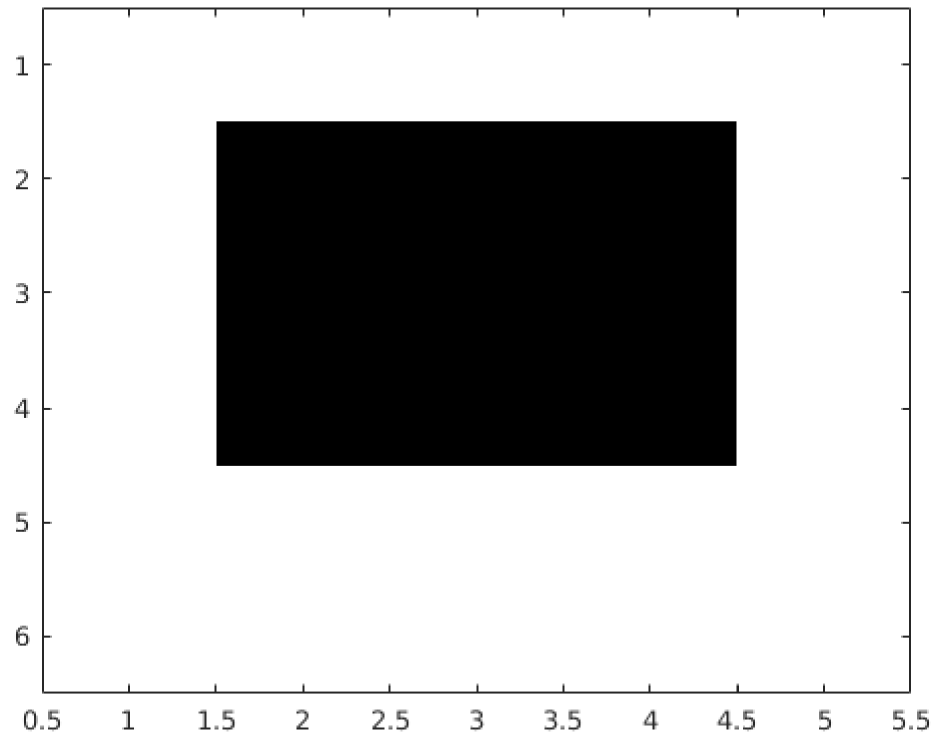
24	16	16	16	24
24	16	16	16	24
24	24	24	24	24
24	24	24	24	24






1
2
3
4
5
6
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5


1
2
3
4
5
6
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5



3. Application 1

In this section, the goal is to segment the black objects in the image 'lille-stor.jpg' before applying a granulometry study. You can check that a simple threshold gives a good result. However, we'll use regional extrema operators in order to well understand these operators.

```
clear all;
close all;
I=imread('lille-stor.jpg');

I=rgb2gray(I);
figure(1), imagesc(I),colormap(gray), title('I'), axis equal
```

3.1. Analysis of the input image

3.1.1. Extract all regional minima using imregionalmin

```
% Code :

Iminr = imregionalmin(I);
figure(2)
imshow(Iminr);
```

Comment : many regional minima

3.1.2. Extract all regional maxima using imregionalmax.

```
% Code :

Imaxr = imregionalmax(I);
figure(3)
imshow(Imaxr);
```

Comment : many regional maxima

To understand the previous results, let's plot a profile.

```
figure(4), imagesc(I),colormap(gray), title('I'), axis equal
%c=improfile() %(2,83,210,83)
% ou
 x = [2 210];
 y = [83 83];
 improfile(I,x,y);
```

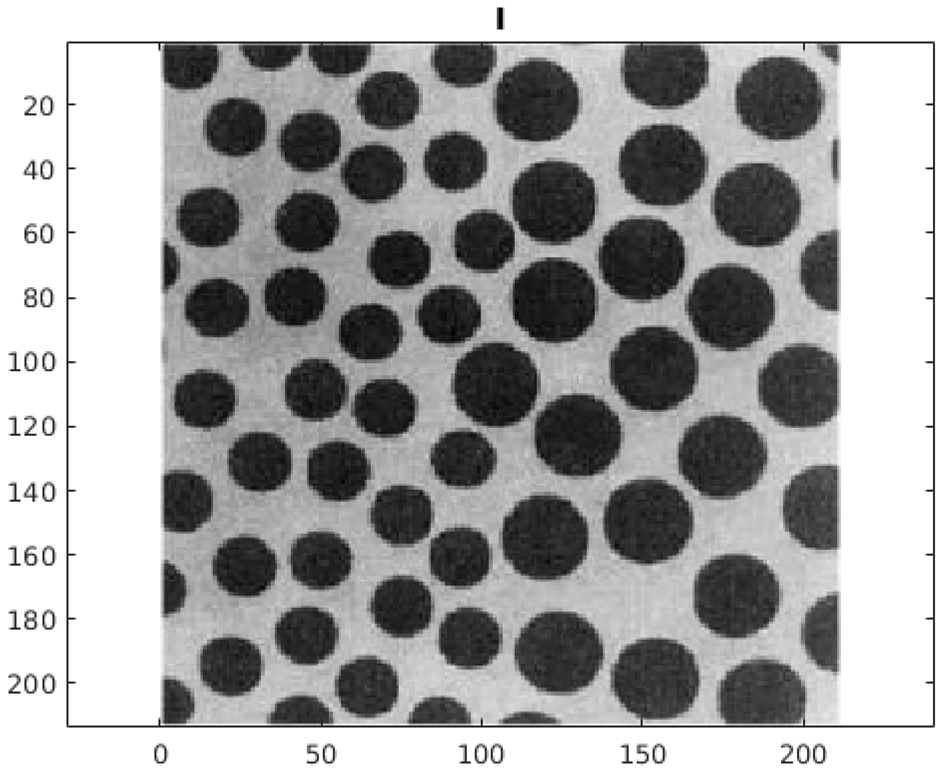
What do you observe ?

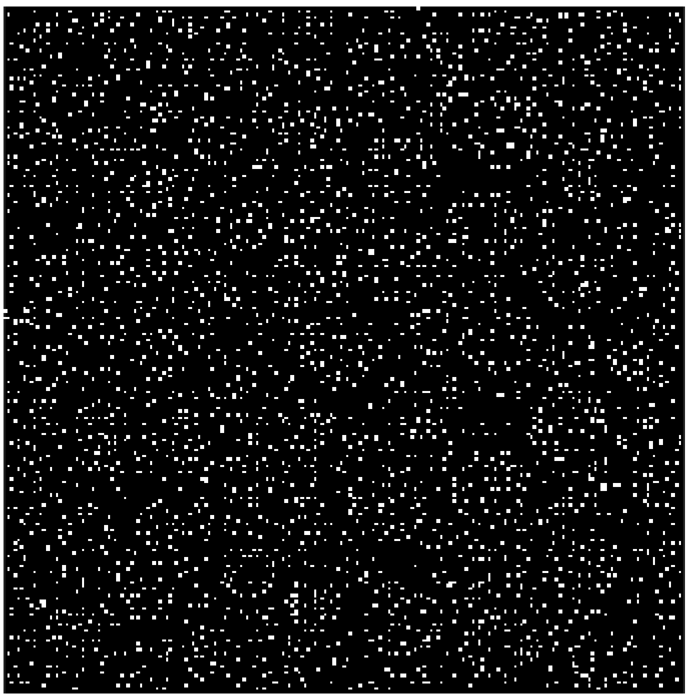
- dérive d'éclairement
- bruit

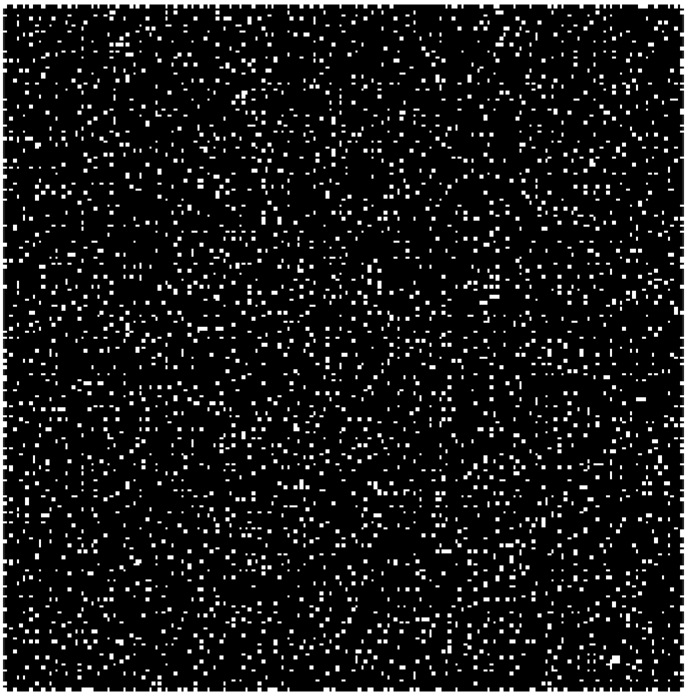
3.1.2. Image segmentation

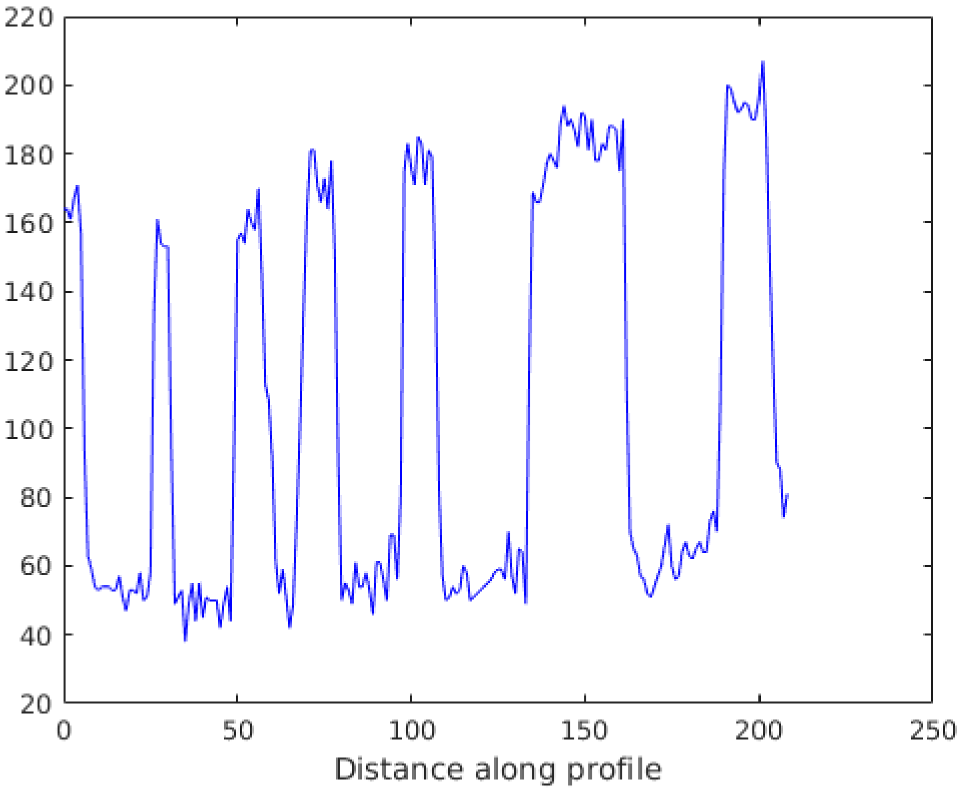
Propose a sequence of processing steps to obtain a binary image with the round objects.
(you can plot the same profile to understand the result of your operations)

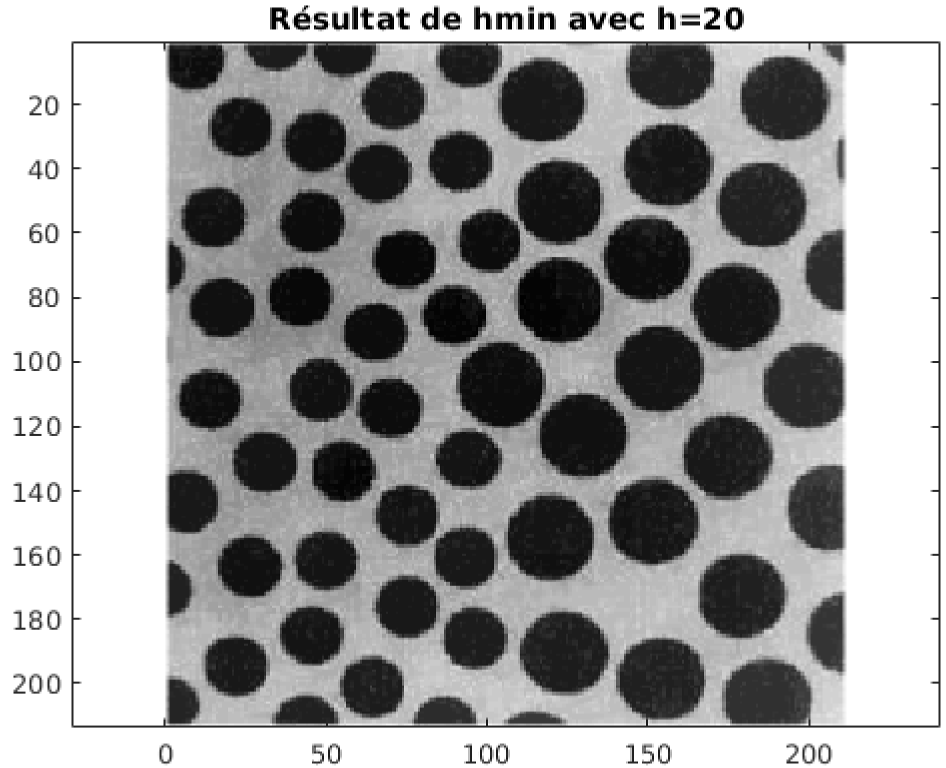
```
% Code:

Ihmin = imhmin(I,20);  %musc 10  blobs :10
figure(5),imagesc(Ihmin),colormap(gray), title('Résultat de hmin avec h=20'), axis equ
figure(6),improfile(Ihmin,x,y);

Ihmin = imhmin(I,40);  %musc 10  blobs :10
figure(7),imagesc(Ihmin),colormap(gray), title('Résultat de hmin avec h=40'), axis equ
figure(8),improfile(Ihmin,x,y);

Ihminmax = imhmax(Ihmin,40);  %musc 10  blobs :10
figure(9),imagesc(Ihminmax),colormap(gray), title('Résultat de hmax avec h=40'), axis
figure(10),improfile(Ihminmax,x,y);

% avec hmin, on remplit les vallées noires
% Extraction des maxima régionaux
mine = imregionalmin(Ihmin);
figure(11), imshow(mine), title('mine')

% on peut faire une petite fermeture pour boucher les trous
B=strel('disk',1);
minecl = imclose(mine,B);
figure(12), imshow(minecl), title('minecl')
```

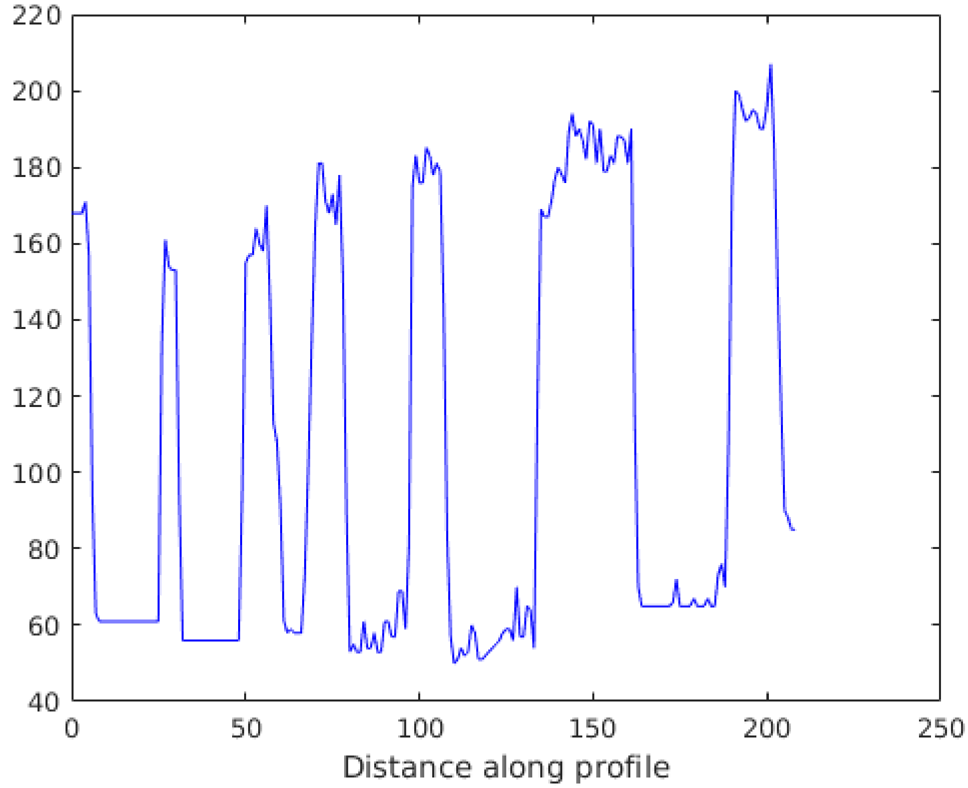

I
20
40
60
80
100
120
140
160
180
200
0
50
100
150
200

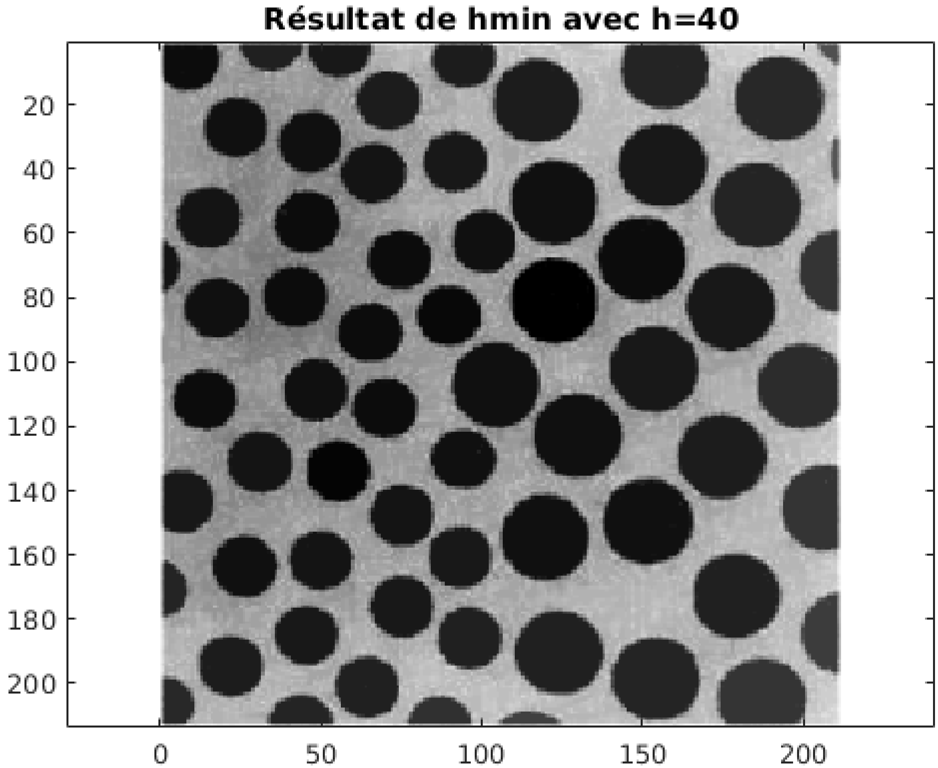


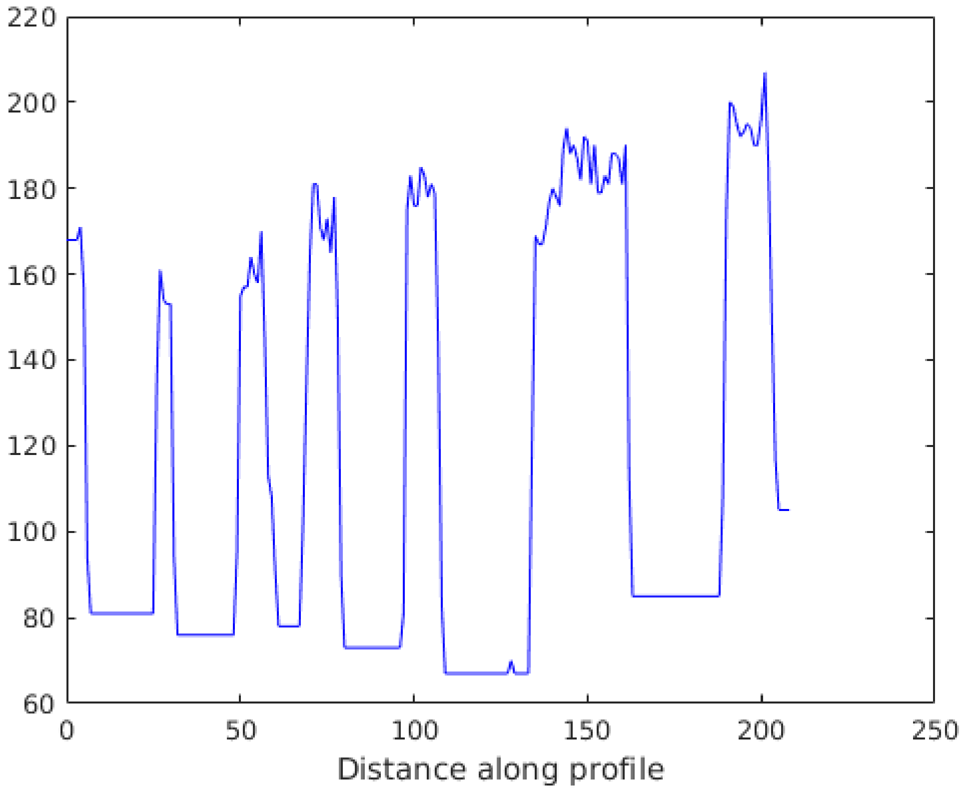


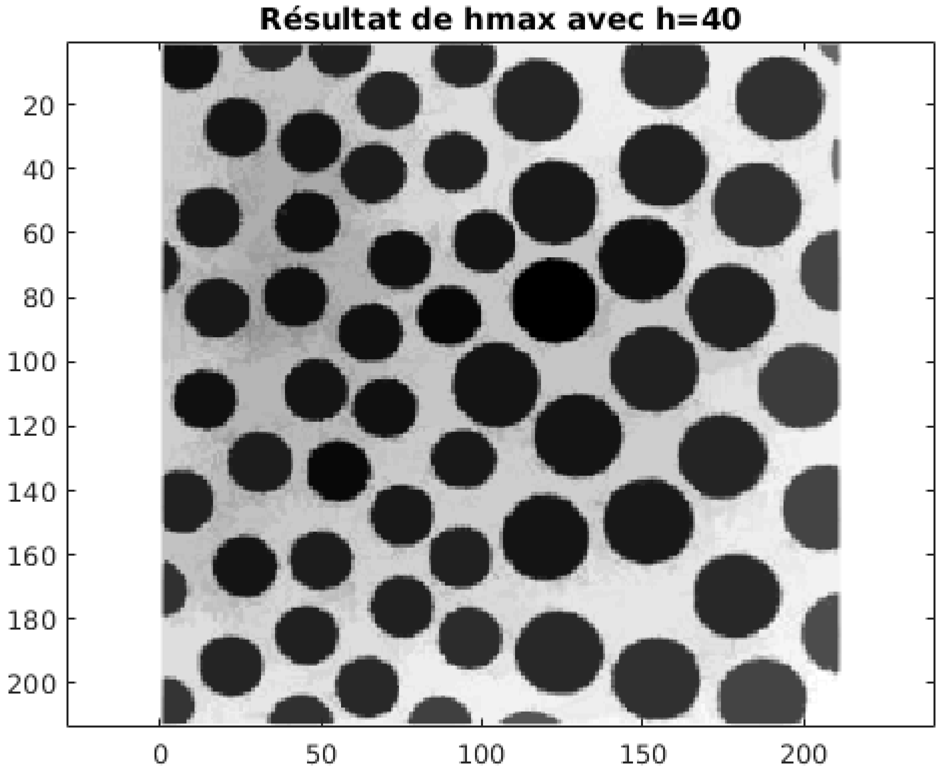

220
200
180
160
140
120
100
80
60
40
20
0
50
100
150
200
250
Distance along profile

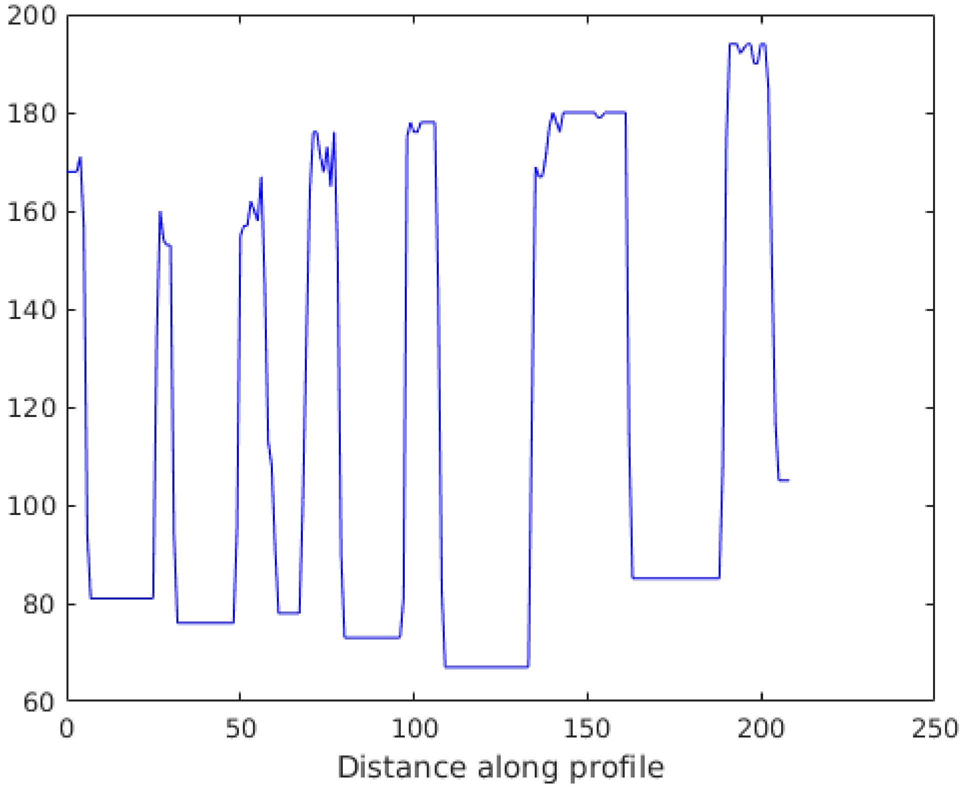

Résultat de hmin avec h=20
20
40
60
80
100
120
140
160
180
200
0
50
100
150
200


220
200
180
160
140
120
100
80
60
40
0
50
100
150
200
250
Distance along profile

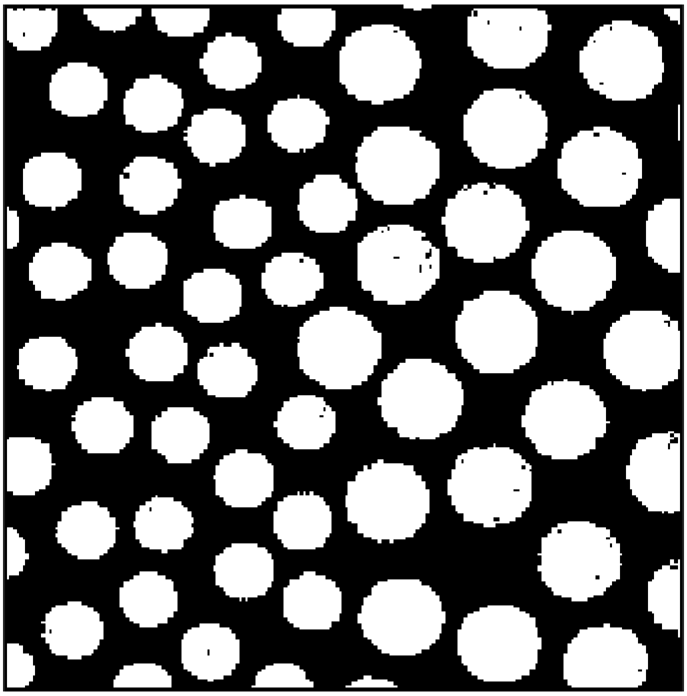

Résultat de hmin avec h=40
20
40
60
80
100
120
140
160
180
200
0
50
100
150
200


220
200
180
160
140
120
100
80
60
0
50
100
150
200
250
Distance along profile

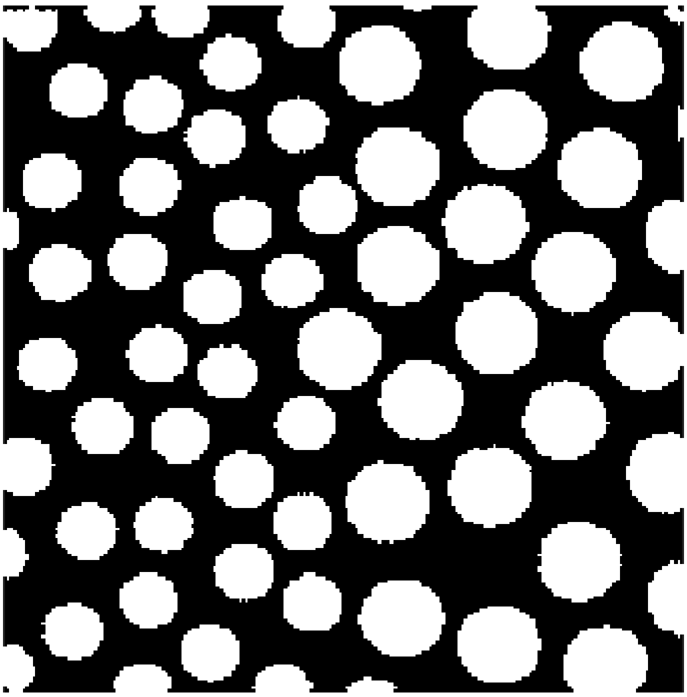

Résultat de hmax avec h=40
20
40
60
80
100
120
140
160
180
200
0
50
100
150
200


200
180
160
140
120
100
80
60
0
50
100
150
200
250
Distance along profile

mine



minecl

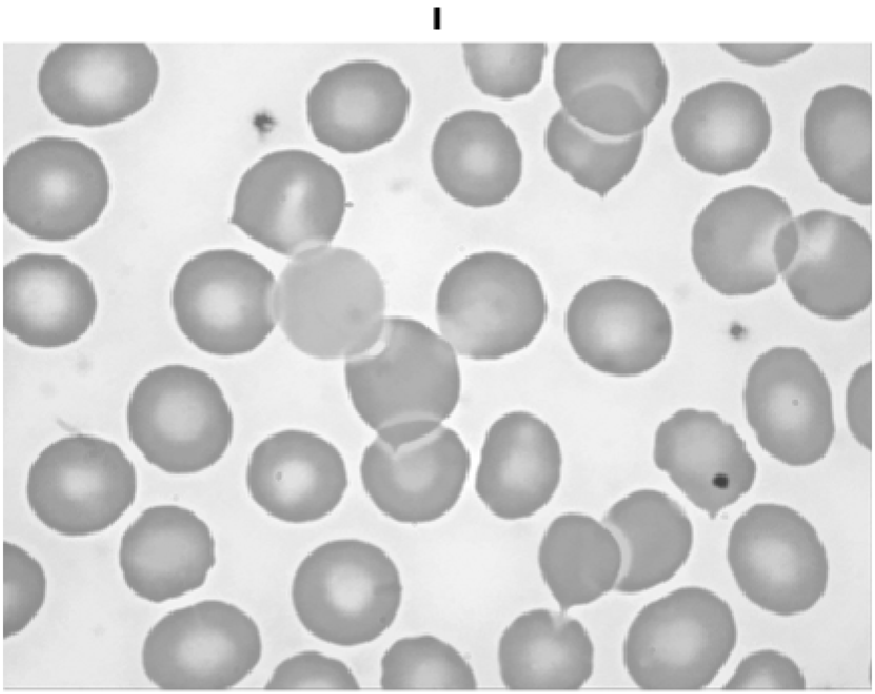


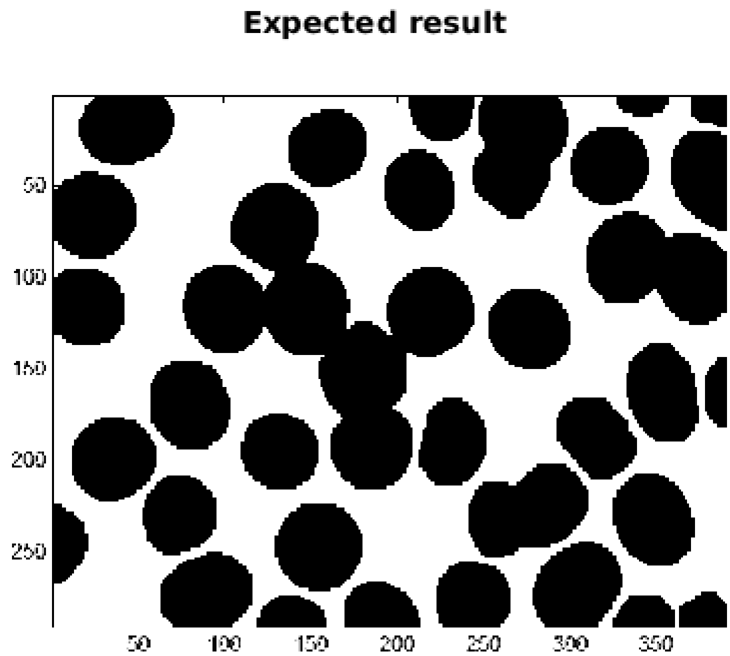
4. Application 2

In this section, the goal is to segment the cells present in the image 'erythrocytes.bmp' without inclusions(small black dots). The obtained result must be similar to the one shown in erythrocytesBin.bmp.

For this application, you can use any tools seen in the Chapter 5.

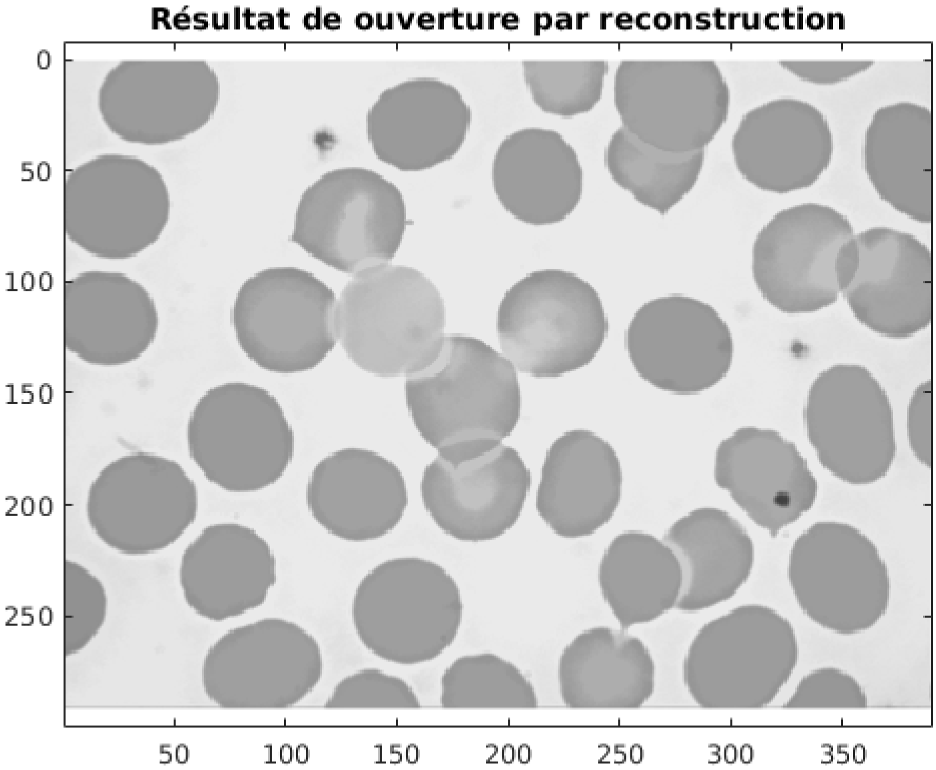
```
clear all;
close all;
I=imread('erythrocytes.bmp');

figure(1), imshow(I),colormap(gray), title('I')
%improfile();
Ires=imread('erythrocytesBin.bmp');

figure(2), imshow(Ires),colormap(gray), title('Expected result')
```

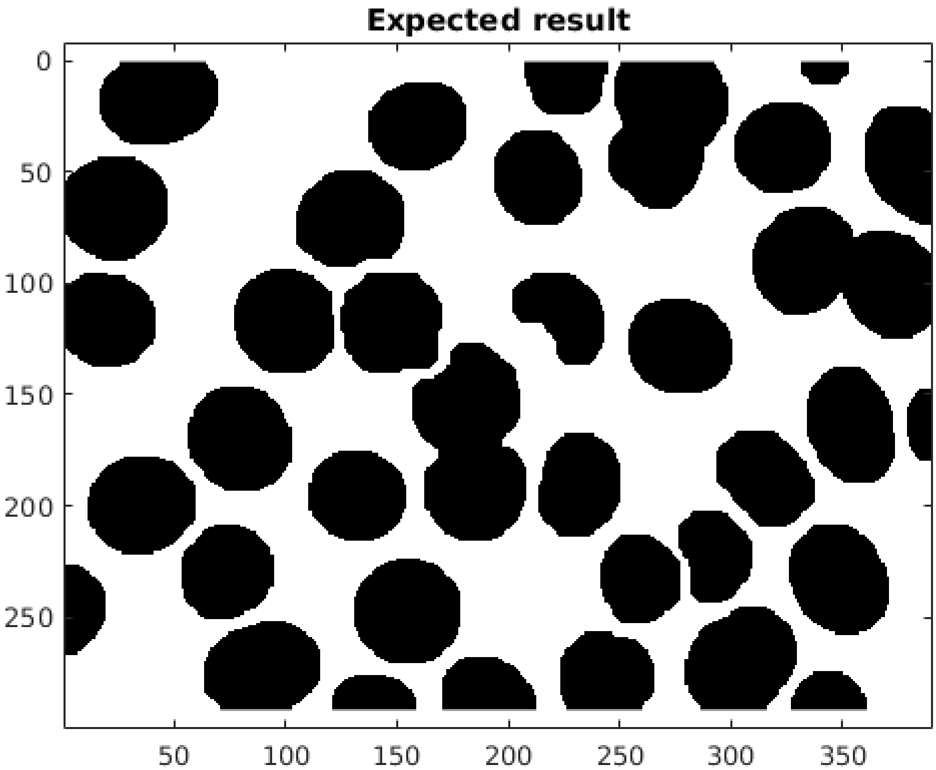




1ère solution : On commence par supprimer les pics lumineux au centre des cellules par une ouverture par reconstruction.

```
B=strel('disk',25);
Iop = imerode(I,B);
Iopr = imreconstruct(Iop,I);
figure(3),imagesc(Iopr),colormap(gray), title('Résultat de ouverture par reconstructi
%improfile();

% filtrage des inclusions noires
B=strel('disk',10);
Ioprcl = imclose(Iopr,B);
Ioprclth = Ioprcl > 200;
figure(4),imagesc(Ioprclth),colormap(gray), title('Expected result'), axis equal
```



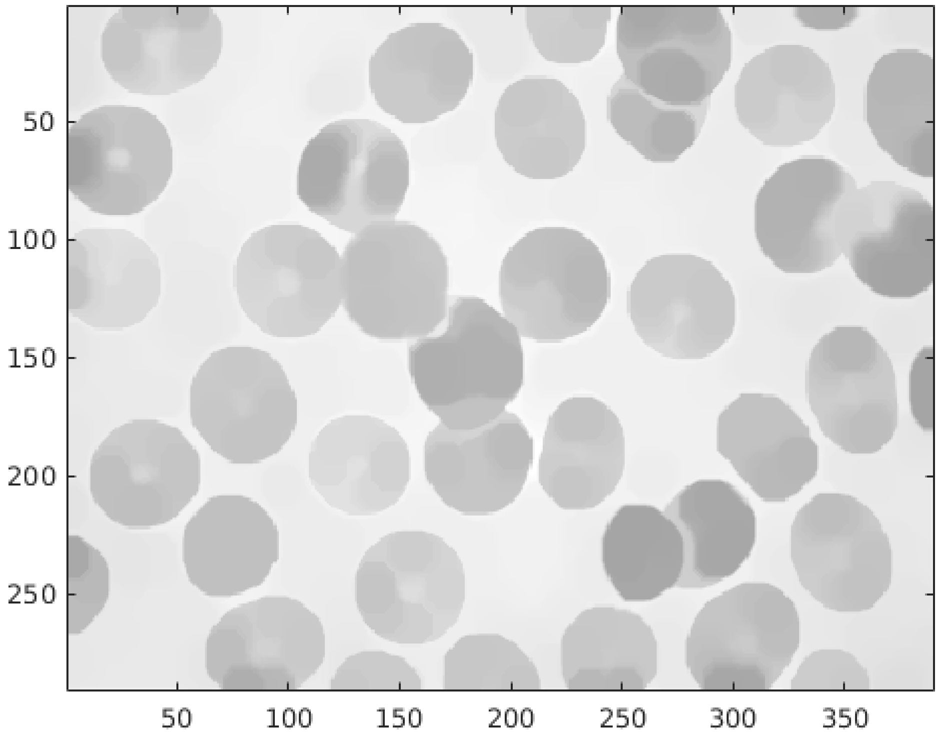


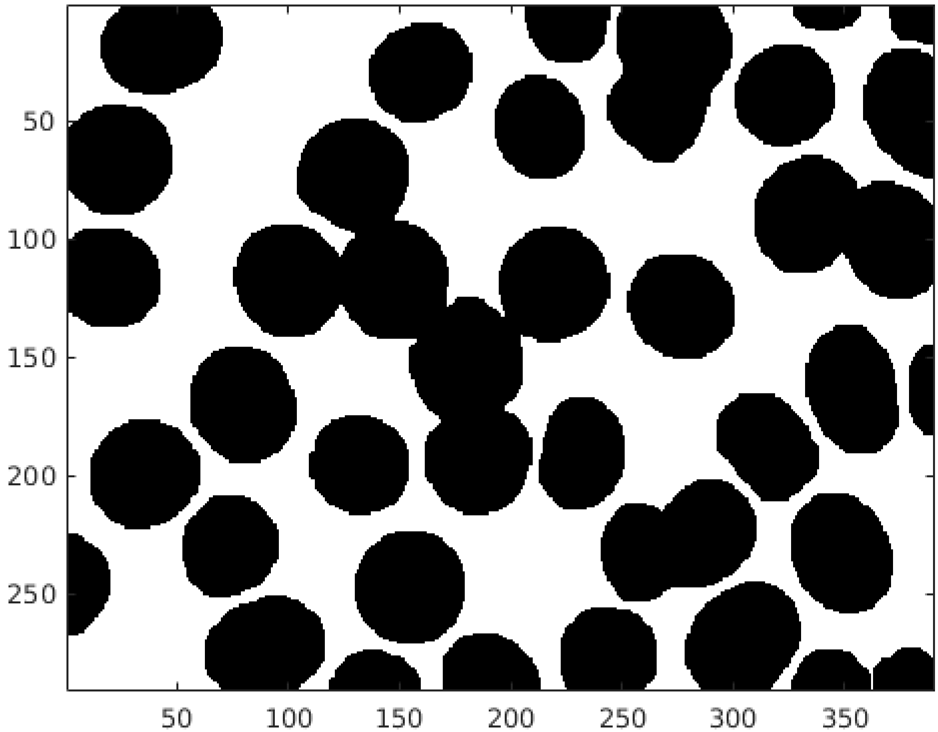
2ème solution : pour cette application, on peut utiliser hmin/hmax pour lisser, puis fermeture des points noirs, comme on vient de le faire.

```
% Meilleure stratégie pour avoir les cellules et leurs zones de superposition.
```

```
% --> détection du fond après lissage!
B=strel('disk',9);
Icl = imclose(I,B);
figure(45),imagesc(Icl),colormap(gray)
Iclmaxr = imregionalmax(imhmax(Icl,29));
figure(5),imagesc(Iclmaxr),colormap(gray),% title('Résultat de la reconstruction à pa
```

Ensuite, sur ce résultat, il faut trouver comment déconnecter les objets (ce qui peut servir d'image d'entrée au TD suivant). En effet, les objets peuvent être déconnectés par LPE.





5. Cell segmentation

Here is an image of blood cells:

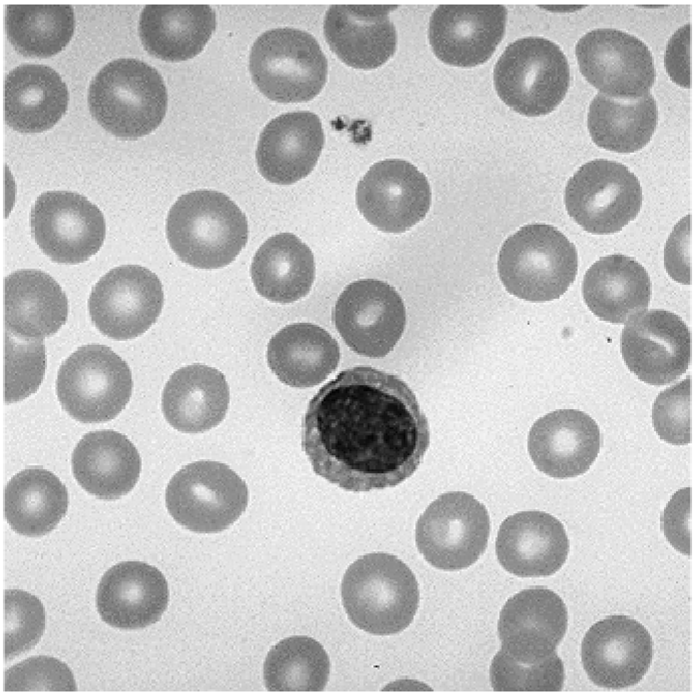
```
clear all
close all

i=imread('blood.tif');
i=rgb2gray(i);
figure(1)
imshow(i,[])
```

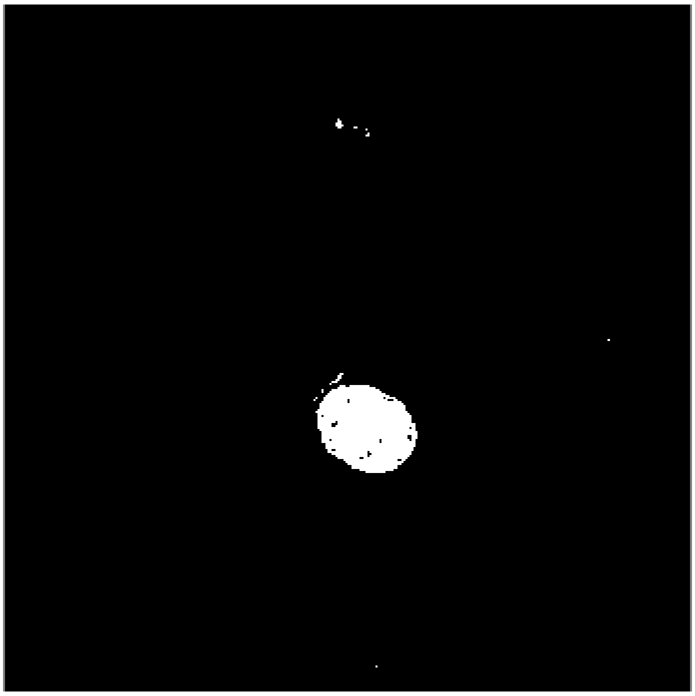
Notice the cell roughly in the middle, it's a white blood cell with it's cell nucleus stained. We want to get ONLY this one cell

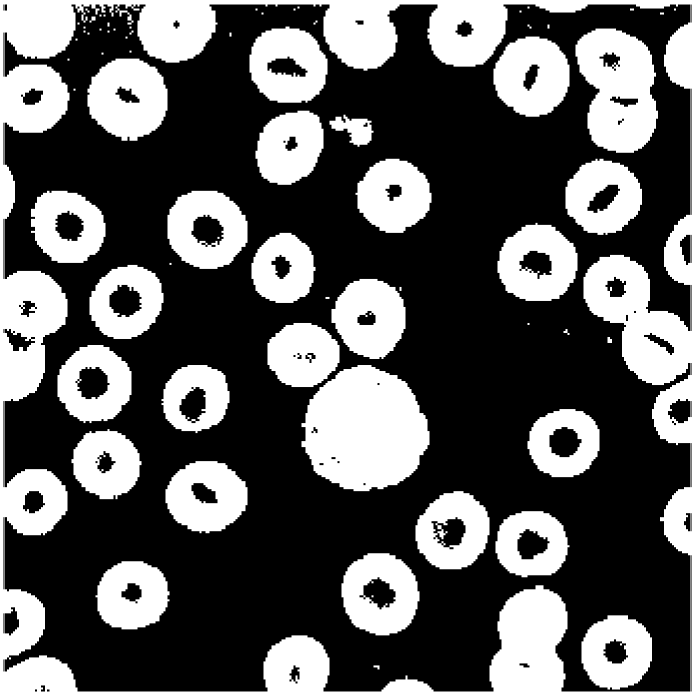
Propose a morphological sequence of operations to get the cell :

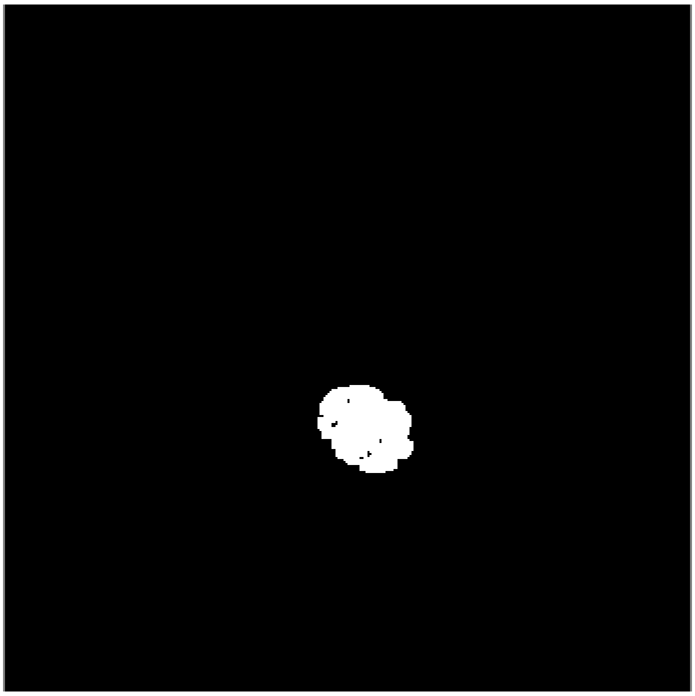
```
% Hmmmmmmm, let's try a thresholding:

it1=i<100;
figure(2)
imshow(it1,[])

% No luck, this gives us just the nucleus.  Let's change threshold

it2=i<180;
```

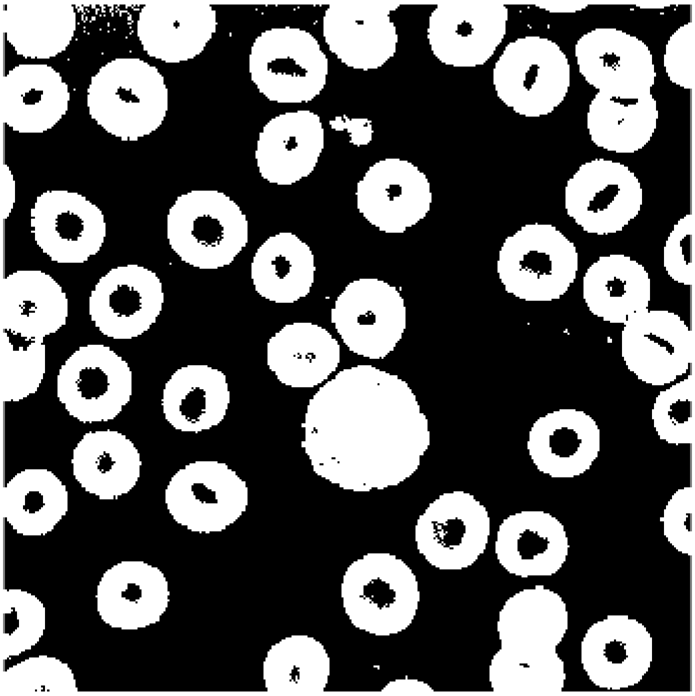
```
figure(3)
imshow(it2,[])

% This gives us roughly what we want, but notice that now we got many other
% cells too.

% Reconstruction to our aid.  Start by thresholding to make a really strict
% marker for the nucleus (we also use an opening to remove some noise)

it1=i<100;
it1=imopen(it1,ones(5));
figure(4)
imshow(it1,[])

% Now lets make a very "loose" threshold

it2=i<180;
figure(5)
imshow(it2,[])

% Now reconstruct the marker under the mask using dilation.

ir=imreconstruct(it1,it2);
figure(6)
imshow(ir,[])

% Lets finish this off by a closing to remove a few interior holes

ir=imclose(ir,ones(3));
figure(7)
imshow(ir,[])

% here  a nice trick to put a red border around our cell
% suppose your result binary image is named ir

irb=bwperim(ir,8);
i(find(irb))=255;
figure(8)
imshow(i,[])

%modification de la lut
map=gray(256);
map(256,:)=[1 0 0];
colormap(map)
```

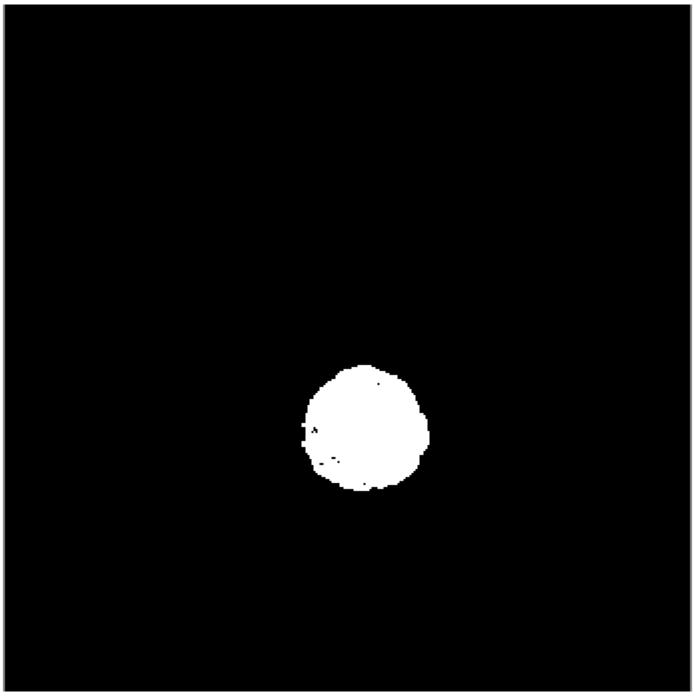


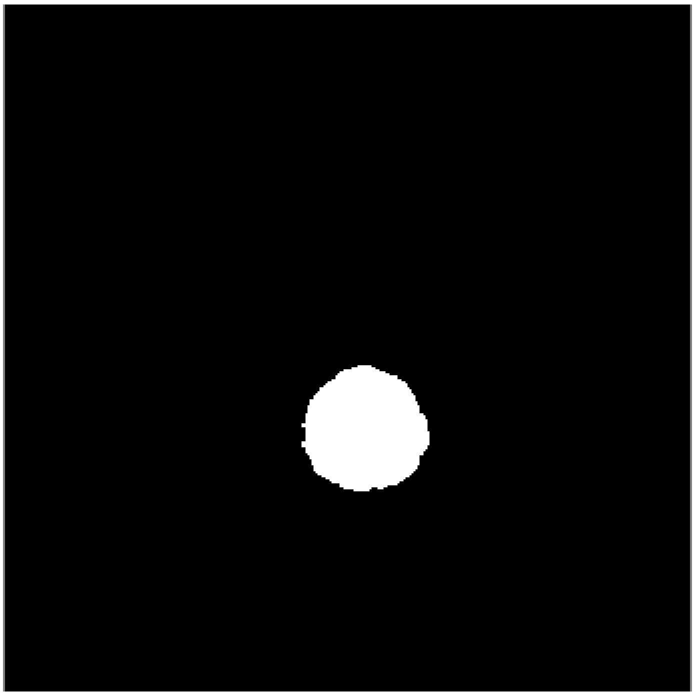


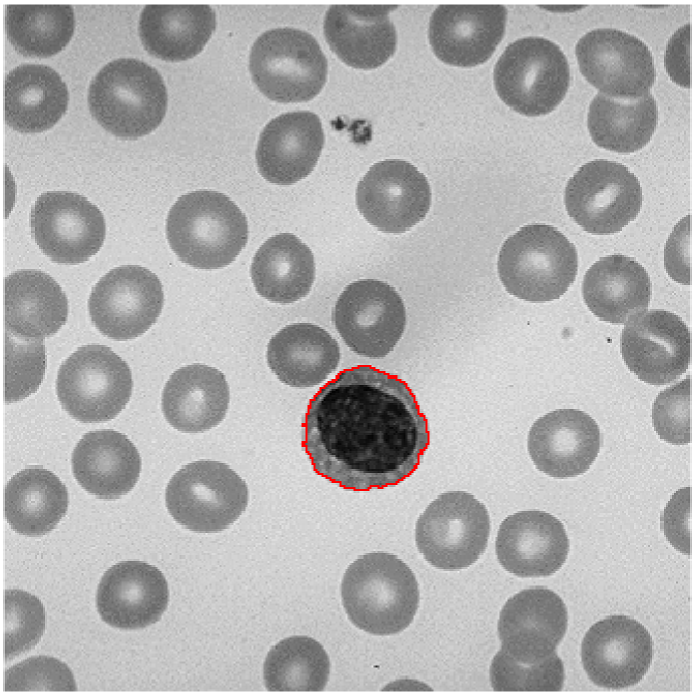












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