Video Signals

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Ex.1.[14 pt] We want to develop a system to automatically count the number of coins in an image.

In particular all the coins are disks of the same size

[6pts.] provide a system to extract coins circular edges removing background and internal part.

[8 pts.] Using the Hough Transform describe how to insulate each circle and to count them.

Es.2. [9 pt] Consider the B/W object on the left, describe the morphological procedure to extract its skeleton.

Describe the whole procedure using this structuring element.
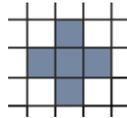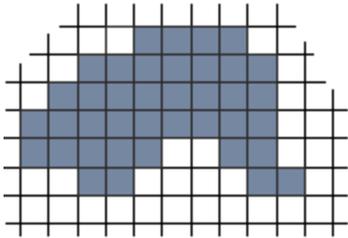
Furthermore, define a stopping condition for the algorithm.

Es.3. [10 pt MATLAB Exercise]

You installed a camera in front of your house in order to monitor the speed of cars driving on the road in front of it. You assume that no more than one car is visible in each frame and no other objects are moving. In particular you want to calculate the speed of the car given three different images: bg.jpg (an image taken without any car), 1.jpg (an image of a moving car), 2.jpg (the second image of the same car taken after 2 seconds). Write a Matlab script able to perform the following steps:

a) Read the 3 input 8-bit color images (each of with the same size [N M]), convert them to double grayscale images and visualize them.

b) In order to detect the moving objects, calculate D1 and D2 defined respectively as the difference between the 1st image and the background and the 2nd image and the background.

c) In order to avoid detection errors due to the movements of small isolated objects, such as leaves, for each of the two images (D1, D2) perform the following operations:

I. obtain a threshold t1 (or t2) equal to 1/10 of the maximum absolute values stored in D1 (or D2)

II. calculate a binary image, B1 (or B2), associating TRUE value to moving pixels. In order to do so, set to TRUE the pixels having an absolute value greater than the threshold.

III. define a square structuring element with size equal to 0.5% of the minimum between M and N.

IV. apply a morphological operation of your choice in order to remove isolated TRUE values from B1 (or B2) obtaining M1 (or M2)

d) Estimate the speed of the car in the following way:

I. find the coordinates of TRUE values in M1 and M2

II. calculate the coordinates of the central point of the car in the two images by averaging the (x,y) coordinates obtained in the previous point

III. knowing that a displacement of 1 pixel corresponds to 0.05 meters (assume that you have calculated this value knowing the intrinsic parameters of the camera and its position in respect to the street), calculate the speed of the car in km/h (remember that the second image is taken 2 seconds after the first one).

Matlab List of possible functions
```
figure
rgb2ind
im2double
imread
imclose
zeros
rgb2gray
imcrop
ones
imopen
imshow
find
hist
min
max
strel
imnoise
abs
round
sum
size
numel
norm
```

Solutions

Ex.1

A possible solution for the first point is to analyse the histogram of the whole image. Since the background is the largest area in the image of almost the same grey intensity, its distribution will be similar to a spike in the histogram.We can then assume as background pixels those whose intensity is close to that spike and make a preliminary segmentation of pixels with an intensity close to that peak with respect to all the others. However some pixels of the same intensity of the background could also be present inside the coins and a further morphological closing can help reducing their presence.

The edge of each coin can be extracted with different approaches, one could be subtracting from the previous black and white image an eroded version of it, or other omnidirectional filter extraction algorithms can be applied.
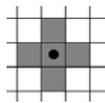
To find the circles of coins'edge, using the idea of Hough transform, we can define for every edge pixel (obtained from the previous step) the pencil of circles of the same radius passing through that point: we can define those pencils as the set of centres of those circles with the same radius.
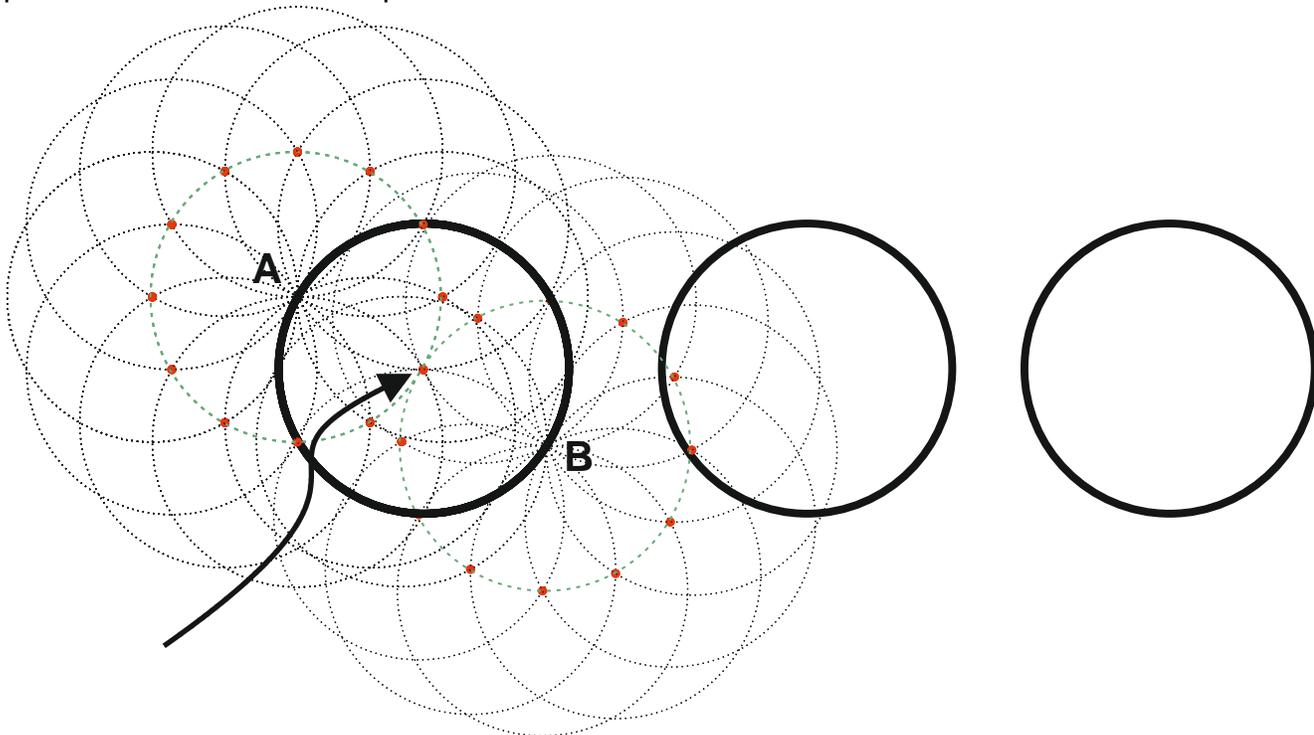

In this image we consider two points, A and B, of the original circle in black. For each of them the Hough transform will consider all the possible circles passing through that point and the centres of these circles are represented in orange (the centres are located in an ideal circle represented by the dashed green line). The Hough transform would accumulate all these centres in the dual space represented, in this case, by the coordinates of the centres and, the maxima of the transform will be in the center of the original circle (indicated by the arrow in the image above).

Ex.2

Using a 3x3 cross structuring element, applying the skeletonization morphological operator, we get the following skeleton hierarchy:
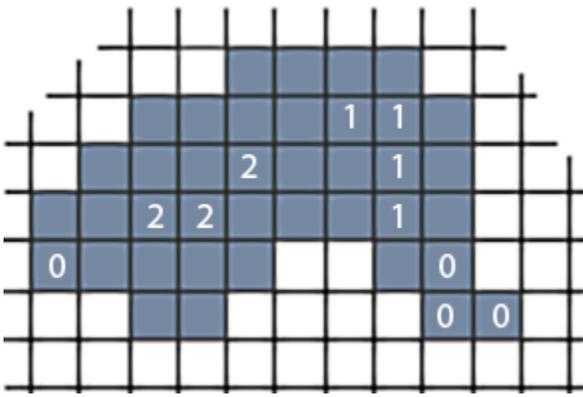
Ex.3

```
close all
clear all

%a)
I1 = imread('1.jpg');
I1 = rgb2gray(I1); I1 = im2double(I1);
I2 = imread('2.jpg');
I2 = rgb2gray(I2); I2 = im2double(I2);
bg = imread('bg_2.jpg');
bg = rgb2gray(bg); bg = im2double(bg);

%b)
D1 = I1 - bg;
D2 = I2 - bg;

%c) I. and II.
B1 = abs(D1)>0.1*max(abs(D1(:)));
B2 = abs(D2)>0.1*max(abs(D2(:)));

%c) III.
n = round( 0.005*min(size(I1)) );
SE = strel('arbitrary',ones(n));

%c) IV.
M1 = imopen(B1,SE);
M2 = imopen(B2,SE);

%d) I. and II.
[i,j] = find(M1);
p_1(2) = sum(i)/numel(i);
p_1(1) = sum(j)/numel(j);
[i,j] = find(M2);
p_2(2) = sum(i)/numel(i);
p_2(1) = sum(j)/numel(j);

%d) III.
p2m = 0.05;
t = 2;%s
v = norm(p_2-p_1)*p2m/t %m/s
v*60*60/1000
```