Medical Image Analysis
Exercise 05 - Morphology

2020

Introduction

The purpose of this exercise is to illustrate morphological operations on images.

As usual you start by creating an empty M-file:

```
edit morphology.m
```

Data

The data and material needed for this exercise can be downloaded from

`http://courses.compute.dtu.dk/02512/`

Make sure that the M-file `imagegrid.m` is placed in you current Matlab directory.

Erosion

The file `Image1.mat` contains a synthetic image created to understand the basic operations erosion and dilation. Load the image and visualise it:

```
load Image1.mat
imagesc(Image1)
imagegrid(gca,size(Image1));
colormap(gca,hot);
```

(imagesc automatically scales the image before showing it).

Exercise 1 *What is the image result if erosion is applied using a 3x3 box kernel? Answer this question with pen and paper.*

Exercise 2 *What is the image result if erosion is applied using a 3x3 disk kernel? Answer this question with pen and paper.*

The Matlab function `strel` is used for creating structuring elements. A 3x3 box can be created using

```
se1 = strel('square',3)
```

and a 3x3 disk by:

```
se2 = strel('disk',1)
```

Read the documentation for the Matlab function `imerode` :

```
doc imerode
```

Exercise 3 *Use* `imerode` *to verify your pen and paper results. Use* `subplot` *to create a plot with both the original and the eroded images.*

Dilation

Exercise 4 *What is the image result if dilation is applied using a 3x3 box kernel? Answer this question with pen and paper.*

Exercise 5 *What is the image result if dilation is applied using a 3x3 disk kernel? Answer this question with pen and paper.*

Read the documentation for the Matlab function `imdilate` :

Exercise 6 *Use* `imdilate` *to verify your pen and paper results. Use* `subplot` *to create a plot with both the original and the dilated images.*

Opening

The opening operation is an erosion follow by a dilation.

Exercise 7 *Implement a Matlab function* `mopen` *that realises an opening operation. The function should take the image and the structuring element as input and return the opened image. Start the function by:*

```
function I2 = mopen(I,se)
%MOPEN Open image.
%   I2 = MOPEN(I,SE) opens the image I with the structuring
%   element SE and returns image I2
```

Test your function on `Image1` *using a 3x3 box SE. Use subplot to plot your results together with the original image.*

Read the documentation for the Matlab function `imopen`.

Exercise 8 *Use* `imopen` *on* `Image1`*. Use subplot to plot the result together with the result obtained with your opening function.*

Closing

The closing operation is a dilation followed by an erosion.

Exercise 9 *Implement a Matlab function* `mclose` *that realises a closing operation. The function should take the image and the structuring element as input and return the closed image.*

Test your function on `Image1` *using a 3x3 disc SE. Use subplot to plot your results together with the original image.*

Read the documentation for the Matlab function `imclose`.

Exercise 10 *Use* `imclose` *on* `Image1`*. Use subplot to plot the result together with the result obtained with your opening function.*

General morphology

Load the image `rects.mat` and display it:

```
load rects.mat
imagesc(rects);
colormap(gca, hot);
title('Original')
```

(do not use `imagegrid`).

Exercise 11 *The goal is to remove all objects that are smaller than 9x9 pixel (the 3 smallest objects) without changing the remaining objects. Do that by designing a suitable structuring element and apply a simple morphological operation.*

You can test different strategies.

Brain CT image

The goal of this exercise is to apply morphology on a real image. The exercise involves both thresholding and morphological operations.

Load the image `brainCT.png` and display it:

```
clear all,close all,clc;
I = imread('BrainCT.png');
imshow(I);
```

The goal of the exercise is to extract the skull bones clearly from the image.

Exercise 12 *Start by inspecting the histogram of the image. Do this by using either* `imhist` *or* `imtool`*.*

Try to find a threshold that separates the bone from the background. Apply the threshold, T:

```
Ibone = (I > T)
```

It is not possible to find a perfect threshold. The goal of the next exercise is to close holes in the bones while trying to keep the overall shape.

Exercise 13 *Experiment with different combinations of opening and closing with different kernel sizes on the binary bone image. You should also try combinations where the kernel used for opening is different from the kernel used in the closing.*

Select your best result from the exercise above and call it `Imask` use this result for the next exercises.

Exercise 14 *Compute the boundary of the bones by use of dilation:*

- *Dilate* `Imask` *with a small kernel*
- *Subtract* `Imask` *from the dilated image*

Show the boundary image.

Exercise 15 *Compute the boundary of the bones by use of erosion:*

- *Erode* `Imask` *with a small kernel*
- *Subtract eroded image from* `Imask`

Show the new boundary image and compare with the previous image. Explain the differences between the images in relation to the used morphological operators.