Introduction to Computer Vision

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Contents

1 Introduction

Mathematical morphology (MM) is a theory and technique for the analysis and processing of geometrical structures, based on set theory, lattice theory, topology, and random functions. MM is most commonly applied to digital images, but it can be employed as well on graphs, surface meshes, solids, and many other spatial structures.

Topological and geometrical continuous-space concepts such as size, shape, convexity, connectivity, and geodesic distance, can be characterized by MM on both continuous and discrete spaces. MM is also the foundation of morphological image processing, which consists of a set of operators that transform images according to the above characterizations.

MM was originally developed for binary images, and was later extended to grayscale functions and images. The subsequent generalization to complete lattices is widely accepted today as MM's theoretical foundation.

Mathematical Morphology was born in 1964 from the collaborative work of Georges Matheron and Jean Serra, at the École des Mines de Paris, France. Matheron supervised the PhD thesis of Serra, devoted to the quantification of mineral characteristics from thin

cross sections, and this work resulted in a novel practical approach, as well as theoretical advancements in integral geometry and topology.

2 Erosion and Dilatation

The is two basic operator in MM: **erosion** and **dilatation**. They both are defined through a **structuring element**, which are similar to a neighborhood relationship.

Question 1 *Define erosion and dilatation from an ensemblist point of view and an functional point of view. Give some properties related to these operators.*

Question 2 *Operate in a binary image and a greyscale image with the* MatLab *commands* `imerode` *and* `imdilate`*. What are the effects on binary and grayscale images? Justify. Try with different structuring elements (different shapes, different sizes).*

Question 3 *Extract internal and external edges of a binary image, and the morphological gradian.*

Question 4 *As an exercise, write an algorithm that show, in the map of Europe, the distance of each pixel w.r.t. the sea.*

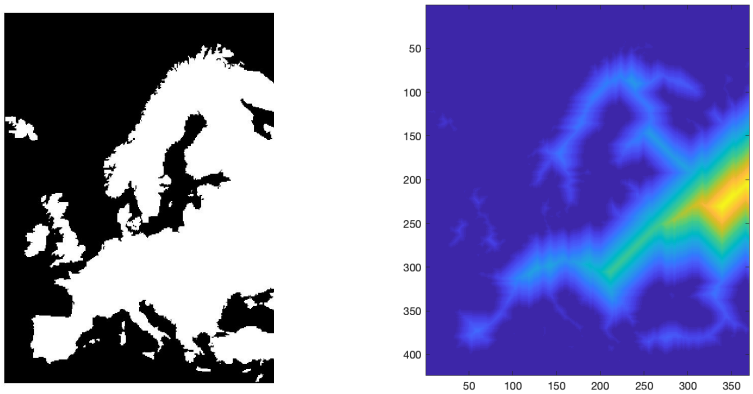

Figure 1: Europe: distance of each pixel *w.r.t.* the sea.

Question 5 *Find an algorithm that detect rectangular objects of 'image2.jpg'.*

3 Morphological Filtering

3.1 Filters

Question 6 *Define the two morphological filters called opening and closing. What are the effects on a binary image sur as 'image1.jpg' (use the commands* `imopen` *and* `imclose`*)?*

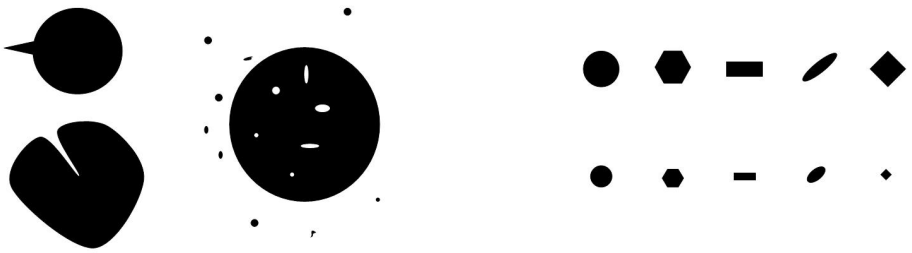

Figure 2: Images.

3.2 Form Detection

Question 7 *The objective being to recognize some forms on images, find a simple algorithm to operate form detection*

Now, imaging image with a salt-and-pepper noise

Question 8 *Apply a salt-and-pepper noise: what's happen with your previous algorithm?*

3.3 Denoising

Question 9 *Use the image* `Nebuleuse.jpg` *and apply a salt-and-pepper noise. De-noise the image by filtering.*

Question 10 *Apply the same process to the 'Spain Beach' image to isolate the beach itself.*

3.4 Top-Hat & Black-Hat Filters

Question 11 *Define op-hat and black-hat process in a 1D function: what is the associated process?*

Question 12 *Define and operate top-hat and black-hat on a greyscale image. What do you observe?*

4 Morphological Skeletonization & Segmentation

Skeletonization is a process that reduce a 2D shapes into 1D shapes. It is defined by the center of maximal circles (a maximal circle cannot be included into another circle) into the 2D shape. Different algorithms exist, such as *"Hilditch's Algorithm for Skeletonization"*.

4.1 Skeletonization Process

The Skeletonization algorithms is based on the following principle: a pixel is part of the skeleton of a given shape if it is in the center of a maximal ball included in the shape. In a practical way, a pixel is selected as the difference between the original shape and the opening of this shape, using successive erosions.

Question 13 *Write and operate a Skeletonization on the diplodocus.*

Figure 3: A diplodocus and its skelette.

Question 14 *Based on skelittization, find an algorithm that operate a segmentation in a binary image. Apply on 'image1.jpg'.*

4.2 Image Segmentation

From this Skeletonization algorithm, it is possible to process an image (quasi-)segmentation as shown Fig. 4.2

Question 15 *Find a Skeletonization algorithm and operate on the Blood Cells image.*

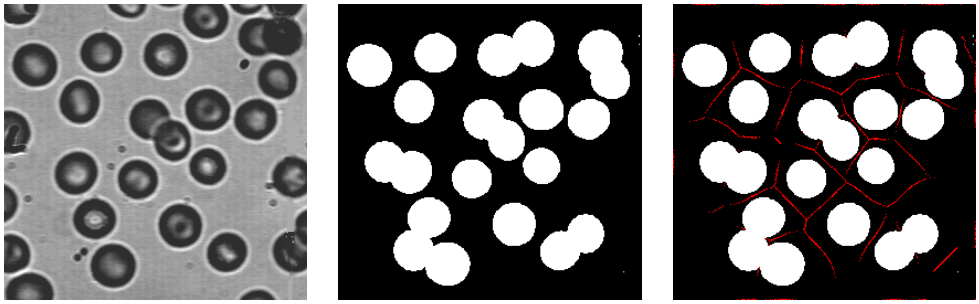

Figure 4: Image Segmentation