ES 331 - Probability And Random Processes

Assignment 04

Image Segmentation using Random Walker Algorithm

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Introduction

Image segmentation is one of the most involved research topics in Computer Vision and has recently attracted a lot of attention. Image segmentation aims to change the image's representation into something more mear analyzed. In this process, an image is partitioned into multiple segments by assigning labels to pixels of the image so that the same label can be characterized as a distinct object present in that image.

The objective is to segment an image into different regions in which each region corresponds to a particular object of interest with the help of the **Random Walker algorithm**. User input is required to initialize the segmentation algorithm (semi-automatic) to segment an image into different regions. User input can be provided in many ways, of which the simplest is the region of interest being outlined by the user with the mouse clicks.

Algorithm:

An image can be presented as an undirected graph G = (V, E), where V and E are the set of vertex and the set of edges, respectively. The set of the vertex V is the set of pixels present in the image. The vertex set can be partitioned into two sets of vertices, "labeled vertices" *Vm*, and "unlabelled vertices" *Vu.*

The set of edges E consists of the pairs of pixels which are neighbors in the image. Depending on the difference between the intensities of the two pixels, the weight of an edge $e = (v_i, v_j)$ is expressed as

$$\omega(vi, vj) = e^{-d(vi,vj)^2/\sigma^2}$$

where $d(vi, vj) = || g(vi) - g(vj) ||$, $and\ g$ means the intensity of pixel.

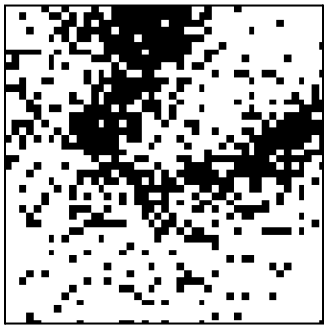
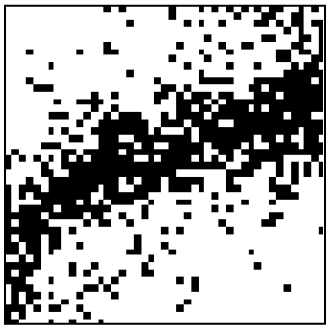
The value of sigma can be set accordingly. The weight of the edge lies in the range (0,1).

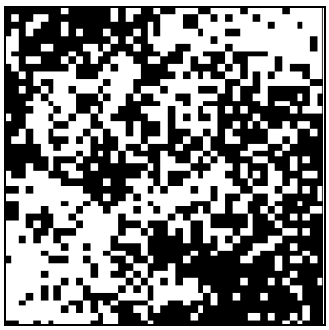
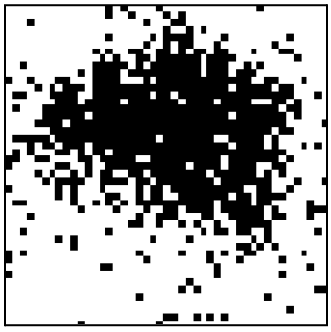
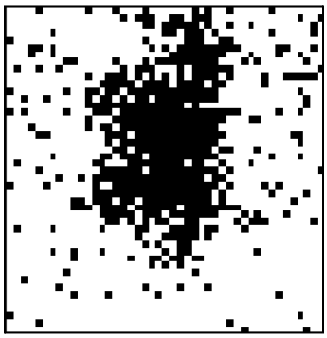
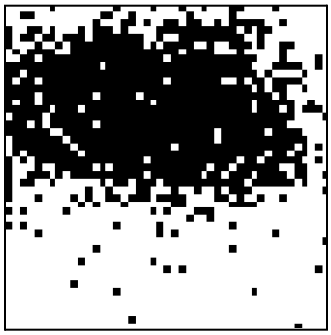
For the case of the random walker algorithm, it is assumed that the image consists of k possible regions of interest, and each labeled vertices lies in any of k ROIs. The weight of the edges can be treated as the measurement of transition probabilities of random walks from one vertex to

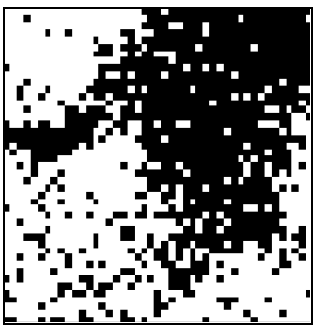
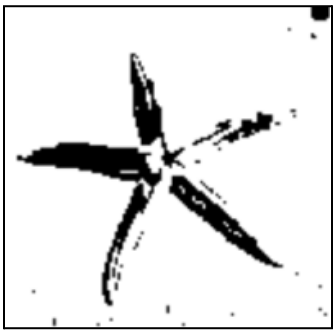
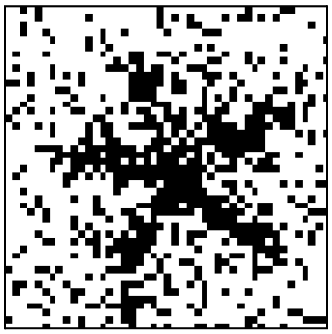
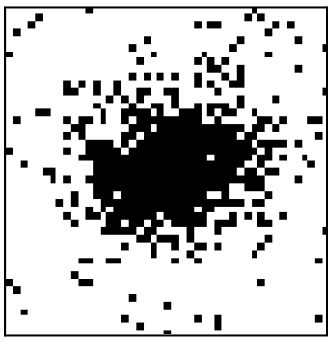
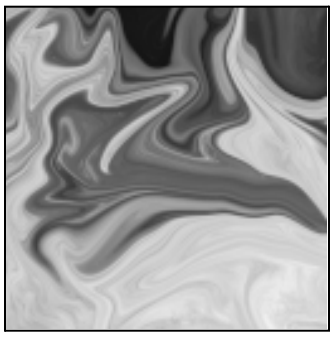
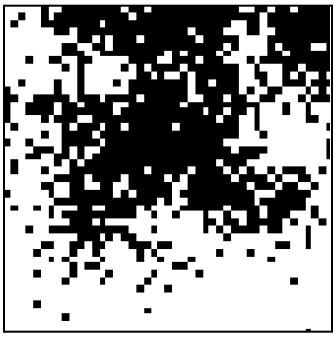
another vertex. The random is likely to transition from *vi* to *vj* if *vi* and *vj* are similar in intensity and is unlikely to make a transition if pixels are dissimilar.

Given the above transition probabilities, we can consider a specific random walk on the graph. In particular, for each unlabelled vertex *vi* belonging to *Vu*; the probability that a random walk beginning at that vertex reaches any of the labeled vertices belonging to a particular object k is computed; this probability is denoted by Pi^{k}. Then the image segmentation is done according to these probabilities. More specifically, for any vertex *vi*, we classify it as belonging to segment k if $Pi^{k} > Pi^{k'}$ for all k' not equal to k. Note that edges in the image (as opposed to edges in the graph) correspond to low transition probabilities, as they involve a rapid change in intensity. Thus, this algorithm will tend to respect image edges in performing the segmentation.

Output:

	Input Image	Segmentation using inbuilt function	Segmentation using user-defined function
1.			
2.			

3.			
4.			
5.			
6.			

7.			
8.			
9.			
10.			

Challenges:

The following challenges were faced in image segmentation:

1. The regions in the image with no distinguishable boundaries are difficult to segment.
2. Labeling of pixels manually in some images affects the segmentation.

Disadvantages:

1. The segmentation accuracy solely depends on the number of labeled pixels. As labeling of pixels is done manually, there are chances of pixels being labeled incorrectly.

2. Labeling pixels is a cumbersome process.

Reference:

1. https://github.com/bnsreenu/python_for_microscopists/blob/master/024-random_walker_segmentation_scikit-image.py
2. https://scikit-image.org/docs/stable/auto_examples/segmentation/plot_random_walker_segmentation.html
3. https://ieeexplore.ieee.org/document/1704833