Assignment 4: Image Segmentation Using Random Walker Algorithm

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(I) Introduction

Image Segmentation is the process of partitioning a digital image into multiple segments. Segmentation helps us to derive the representation of an image that is more useful and meaningful to be analyzed. Image Segmentation has many useful applications, the major being in medical imaging (must be obvious), traffic light systems, etc. One of the techniques of image segmentation is using the famous Random Walker Algorithm. It has been shown to produce amazing results.

The dataset given in the assignment has been used and can be found here.
The Google Colab file for the same can be found here. It consists of the final code for the assignment.

(II) Algorithm of Image Segmentation Using Random Walker

1. The image intensities are mapped to the edge weights using the weight function, as defined in [1] and also in the code.
2. A certain number of labeled pixels are chosen in any manner (For example, in this case, I have used the equalizer function to divide the image into two segments.)
3. After classifying the pixels that lie within the threshold, the rest of the pixels are further classified based on certain conditions. An equivalent circuit is made and alternatively, circuital laws could be used to solve for the so-called *potentials* for the other pixels.
4. The final segmentation is obtained by classifying all the pixels as either of the labels, with the labels being assigned some values initially.

(III) Implementation of the Algorithm

In this assignment, only two labels have been considered initially. The input image is denoised in order to remove the values of pixels that have low frequencies. This image is then equalized to have only a couple of values having high frequencies, which are then used to classify some of the pixels, forming the initial *Marked* image. The Random Walker is then defined using the weight function and thresholds to assign labels to the other segments of the image. Some intermediate images could be seen below:

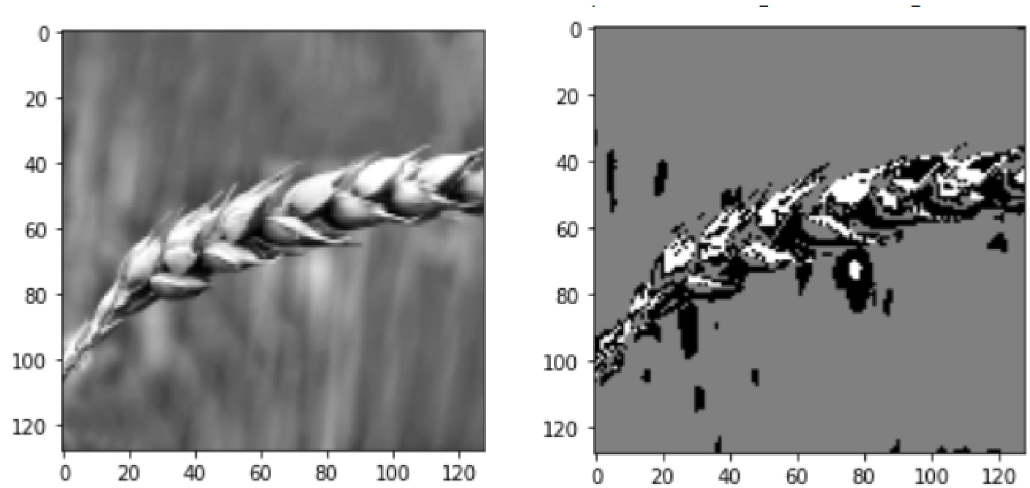

Fig 1. (a) Denoised Image ; (b) Image after Initial Marking

(IV) Results and Inference:

On performing the steps mentioned in the algorithm, a segmented image for one of the images has been shown when (a) Defined Random Walker was used and (b) In-Built Random Walker was used.

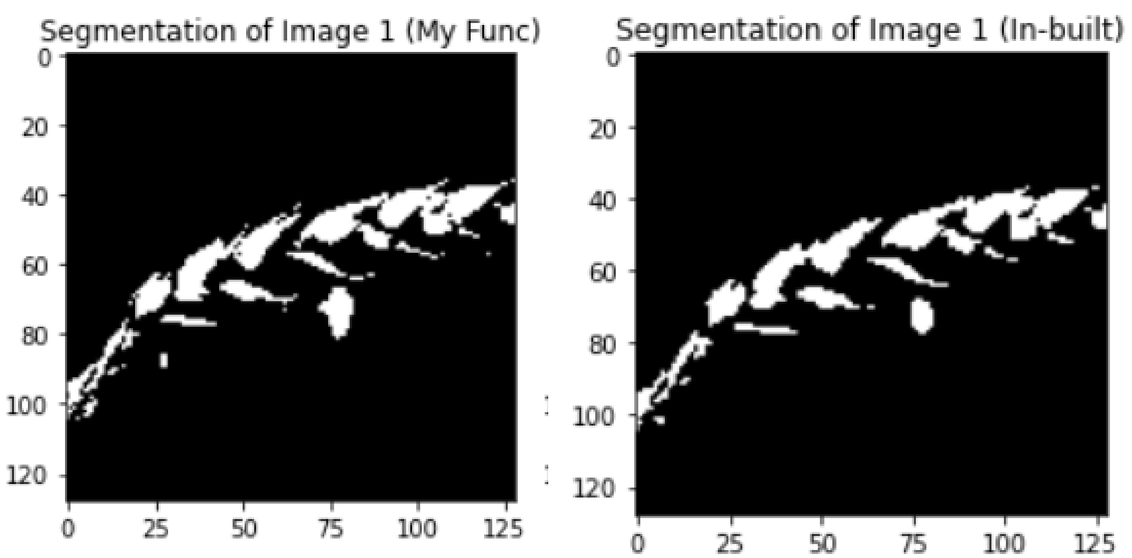

Fig 2. Segmentation using (a)My Function ; (b) In-Built Function

For comparison purposes, a metric called SSIM (Structural Similarity) is being used. A good value of SSIM should be as close as possible to 1. A value greater than 0.99 is observed for all images as shown.

```
SSIM for Image 0 is: 0.9827772959471092
SSIM for Image 1 is: 0.9996166985617985
SSIM for Image 2 is: 0.9990171970830073
SSIM for Image 3 is: 0.9989604218060816
SSIM for Image 4 is: 0.9994448086312281
SSIM for Image 5 is: 0.9965880274104739
SSIM for Image 6 is: 0.9994419055962663
SSIM for Image 7 is: 0.9919123718265824
SSIM for Image 8 is: 0.9998706086541438
SSIM for Image 9 is: 0.9985813316734353
```

(V) References:

[1] L. Grady, "Random Walks for Image Segmentation," in *IEEE Transactions on Pattern Analysis and Machine Intelligence*

[2] GitHub Repo1: Link

[3] GitHub Repo2: Link