Image Segmentation: Level Set formulation

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1 Overview : What is image segmentation ?

Image Segmentation is the process of partitioning a digital image into multiple image segments, or image regions, in order to simplify the representation of an image into something that is more meaningful and easier to analyze. It is typically used to locate objects or boundaries. More precisely, image segmentation is the process of assigning a label to every pixel in an image such that pixels with the same label share certain characteristics.

2 Level set formulation for image segmentation

If we want to explain the level set formulation it is easy : there is a surface, it intersects a plane, that gives us a contour and that's it !

With image segmentation, the surface is updated with forces derived from the image.

The basic idea of the level set formulation is as follows :

1. **Initialize the image separator (contour) with guess**
2. **Let the curve evolve over time** : This needs to define an equation that defines the movement
3. **Stop at a desired boundary**

To do so we introduce a surface $\phi : x \mapsto \mathbb{R}$. We set $\phi(x) = 0 \ \forall x \in$ the contour of interest in the image domain. and we set $\phi(x) < 0$ in the foreground and $\phi(x) > 0$ in the background.

3 Numerical Results

We conclude this work by presenting numerical results using our model on various synthetic and real images, with different types of contours and shapes.

In our numerical experiments, we generally choose the parameters as follows : $\lambda = 10^{-4}$. We only use the approximations $H_{2,\eta}$and $\delta_{2,\eta}$ of the Heaviside and Dirac delta functions ($\eta = \epsilon = 1$), in order to automatically detect interior contours and to insure the computation of a global minimizer. We change the number of iterations for every experience to ensure convergence.

For every experience, the initialization of the mask is specified by using a polygonal region of interest.

3.1 Artificial example

3.1.1 Separate one coin

We start by testing our algorithm on a simple hand-created example shown in figure 1

FIG. 1 – Hand made example

On figure 2, we see the evolution of the mask to detect the edges of **one** cercle.

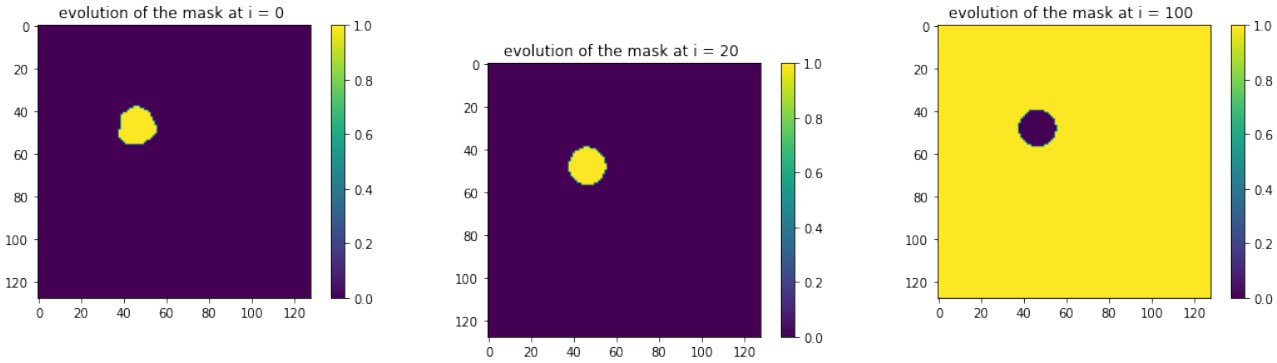

FIG. 2 – mask through the iterations to detect one circle

3.1.2 Separate two coins

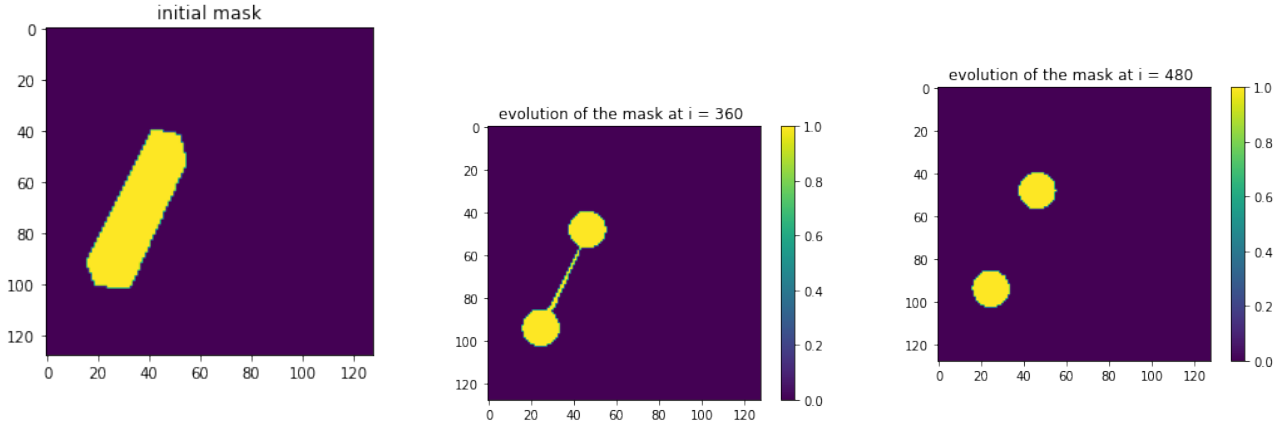

FIG. 3 – mask through the iterations to detect two circles

3.1.3 Separate all coins

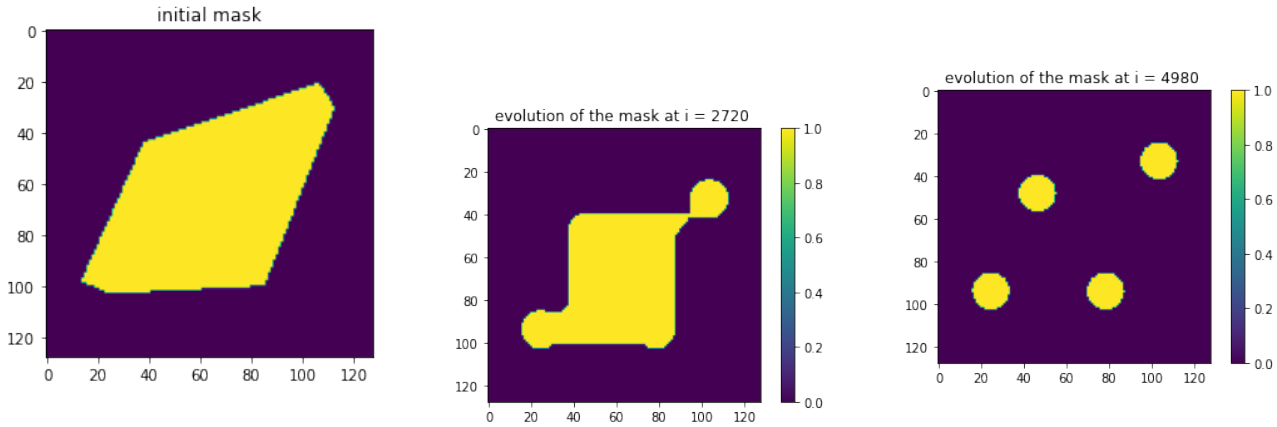

FIG. 4 – mask through the iterations to detect all circles

3.2 A more complicated test : Cameraman

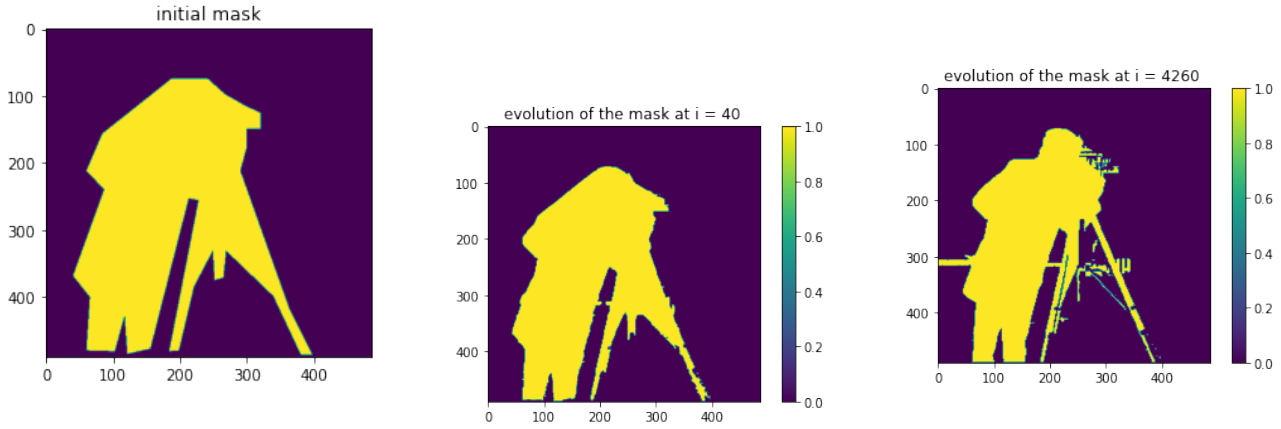

FIG. 5 – mask through the iterations to detect the cameraman

3.2.1 Comments on the results

The example of the coins show that the level set formulation is efficient for image segmentation, we visually obtain segmented parts of the image. This example shows some limitations of the level set formulation for image segmentation. This approach is very sensitive to initial conditions and should be placed usually near to the boundary of objects of interest. Besides, due to the explicit parameterization of the model, this approach cannot cope with significant protrusions and topological changes as shown in the cameraman example.