GRADIENT VECTOR FLOW (GVF) ASSIGNMENT 2

Nivin Pradeep Kumar
S4035593
University of Groningen

Cendur Vishal Karthik Khanna
S3878732
University of Groningen

ABSTRACT

Snakes, or active contours, are used extensively in computer vision and image processing applications, particularly to locate object boundaries. In this report we analyze and study the strengths, and weaknesses of Gradient Vector Flow snakes and compare it with the classical snakes.[1]

Index Terms— Gradient Vector Flow, classical snakes, active contours, snake-based segmentation

1. INTRODUCTION

Snakes or or active contours, are curves defined within an image domain that can move under the influence of internal forces coming from within the curve itself and external forces computed from the image data. Gradient Vector Flow(GVF) are dense vector fields derived from images by minimizing a certain energy functional in a framework. [1] In this report we get an overview of GVF and find it's difference with classical snake.

2. EXERCISE 1

In this exercise we try to fit the Gradient Vector Flow and classical snakes on the U-shape image and observe the differences between the two methods.

2.1. Gradient Vector Flow on U-shape

First we tried to fit the GVF curve with the default parameters and default iterations i.e.,40. We observed a dip in the GVF curve but it did not fit the U-shape image completely. So we increased the number of iterations to 80 which resulted in the GVF curve fitting perfectly. The below Figure 1 shows the GVF curve with 80 iterations fitting completely on the U-shape image.

2.2. Classical snakes on U-shape

Now we used the classical snakes curve to fit on the U-shape image and observed the images. We tried to find the dip by gradually increasing the number of iterations. A small dip started to form at 100 iterations and slightly increased as we increased the iterations. After 300 iterations the dip became constant and there was no change to the classical snake curve after that. The below Figure 2 shows the classical snake

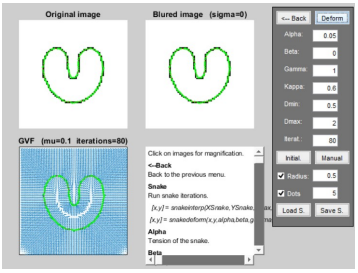

Fig. 1. GVF with 80 iterations on U-shape image

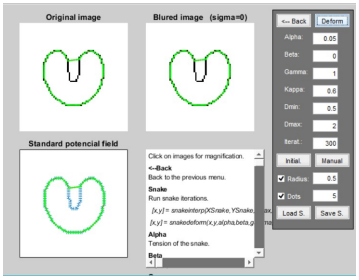

Fig. 2. Classical snakes with 300 iterations on U-shape image

curve with 300 iterations and as we can see the curve does not fit completely on the U-shape image and does not converge completely into the dip.
As we can see from Figure 1 and Figure 2, the GVF curve is better than the classical snakes as it takes significantly less number of iterations to fit perfectly on to the U-shape image. Also even with enough iterations the classical snakes do not converge in to the dip in the figure.

3. EXERCISE 2

In this exercise we try to fit the Gradient Vector Flow and classical snakes on the room image and observe the differences between the two methods.

3.1. Gradient Vector Flow on room image

First we tried to fit the GVF curve with the default parameters and default iterations i.e.,40. We observed the GVF curve fitting the room image completely. There was a straight line at the gap on the top and bottom and there was no outward curve.

The below Figure 3 shows the GVF curve with 40 iterations

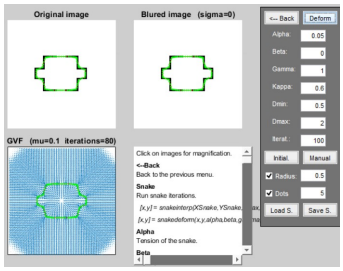

Fig. 3. GVF with 40 iterations on room image

fitting completely on the room image with no outward curves.

3.2. Classical snakes on room image

First we observed the classical snakes with the default parameters and default iterations i.e.,40 having a lot of outward curves in place of sharp edges. So we tried the straighten the curves by gradually increasing the number of iterations. The classical snakes started to fit the room image slowly and at 400 iterations there was a straight line at all the edges and at the gap on the top and bottom with no outward curve.

The Figure 4 shows the classical with 400 iterations fitting

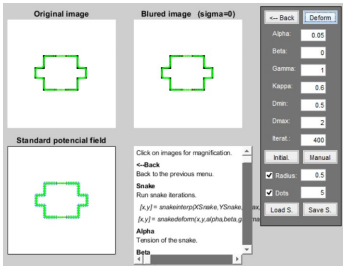

Fig. 4. Classical snakes with 400 iterations on room image

completely on the room image with no outward curves.

As we can see from Figure 3 and Figure 4, the GVF curve is better than the classical snakes as it takes significantly less number of iterations to fit perfectly on to the room image.

4. EXERCISE 3

In this exercise we use GVF and classical snakes to try and segment the left and right lung in the *chest.pgm* image and also observe the differences between the two methods. We use the *mychest.mat* and *mychest2.mat* as initail positions to segment left and right lung respectively.

4.1. Gradient Vector Flow on *chest.pgm*

First we use GVF curve to segment the left lung with the default paramteters and 40 iterations and observed the nearly perfect segment with a small part not covered by the curve. So we increased to 80 iterations and the curve perfectly fit the left lung.

Next we used GVF to segment the right lung and the curve

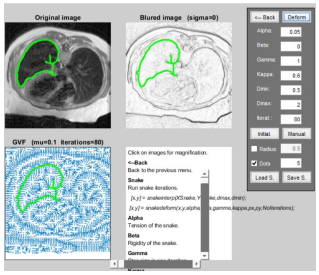

Fig. 5. GVF with 80 iterations on *left lung*

segmented the right lung perfectly even with the default parameters and 40 iterations.

The Figure 5 and Figure 6 shows the GVF segmentation of

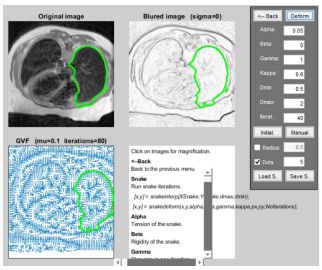

Fig. 6. GVF with 40 iterations on *right lung*

the left and right lung.

4.2. Classical snakes on *chest.pgm*

First we segment the left lung using classical snakes with the default parameters and 40 iterations and observed curve to be smaller than the lung. So we gradually increased the number of iterations and changed the paramaters to try and fit the curve on the lung. But after 80 iterations there was no change to the curve and it did not perfectly segment the lung.

Next we tried to segment the right lung using classical snakes and gradually increased the iterations and changed the parameters to try and fit the curve. At 200 iterations the classical snake nearly fit the whole right lung but further increasing did not have any change on the curve.

The Figure 7 and Figure 8 shows the classical snake segmentation of the left and right lung with the different parameters modified to observe the curve.

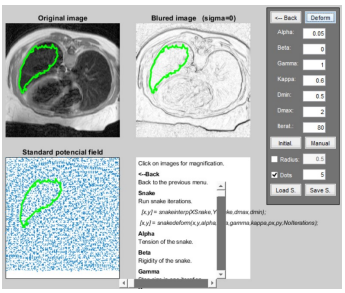

Fig. 7. Classical snakes with 80 iterations on *left lung*

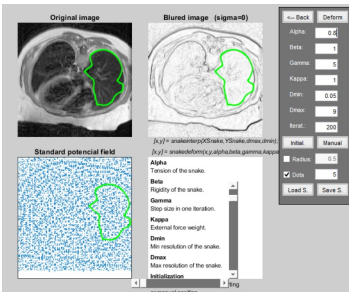

Fig. 8. Classical snakes with 200 iterations on *right lung*

5. EXERCISE 4

In this exercise we load *new.pgm* which has contrast compared to the image used in the last exercise and we use *new1.m* for initialization. We use both GVF and classical snake to segment the left part of the heart.

5.1. Gradient Vector Flow on *new.pgm*

We segment the heart with the help of GVF with an iteration of 40 and after that an iteration of 80. The snake was only able to partially segment it.
Given below figure 9 is the segmentation obtained after doing 40 iteration and figure 10 shows the segmentation obtained after 80 iteration.

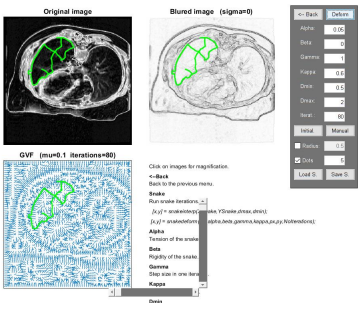

Fig. 9. GVF with 40 iterations

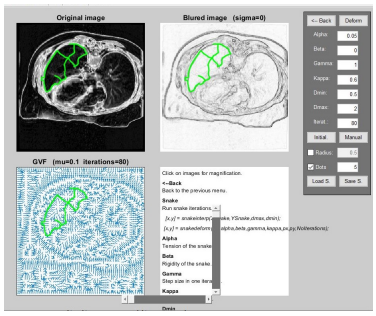

Fig. 10. GVF with 80 iterations

5.2. Classical snake on *new.pgm*

We segment the heart with the help of classical snake with an iteration of 40 and after that an iteration of 80. The snake was only able to partially segment it.
Given below figure 11 is the segmentation obtained after doing 40 iteration and figure 12 shows the segmentation obtained after 80 iteration.

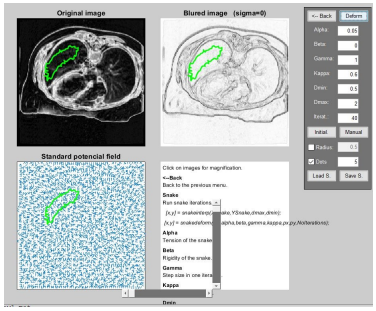

Fig. 11. Classical snakes with 40 iterations

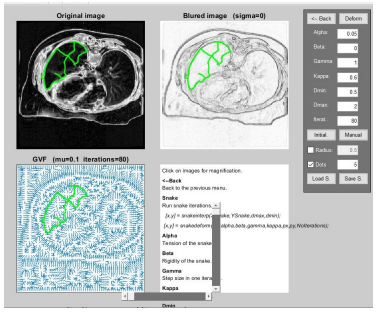

Fig. 12. Classical snakes with 80 iterations

Verifying from the above we can say that having a high contrast image does not help with segmentation.

6. EXERCISE 5

In this exercise we load *heart.pgm* and we use *heart.mat* and *heart1.mat* for initialization. We perform GVF and classical

snake on the data to get the segmentation. We perform the experiment by varying the value of sigma.

6.1. GVF and classical snake with sigma value 0

We use GVF snake and classical snake to segment the data. Figure 13 and figure 14 shows the result for segmentation when initialization data of *heart.mat* is used at sigma value equal 0 for iteration of 40.

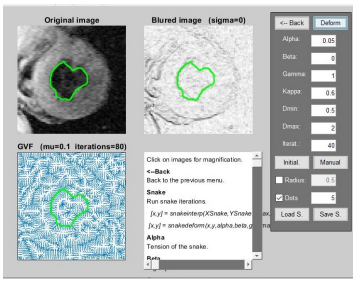

Fig. 13. GVF with 40 iterations

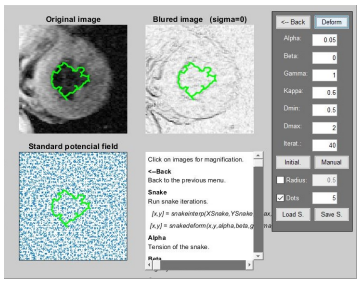

Fig. 14. Classical snake with 40 iterations

6.2. GVF and classical snake with non-zero sigma value

We experiment with both classical and GVF to segement the data with sigma value of 5. We found out that rate at which segmentation happens increases for classical snake but decrease for GVF. Figure 15 and figure 16 shows the segmentation of data.

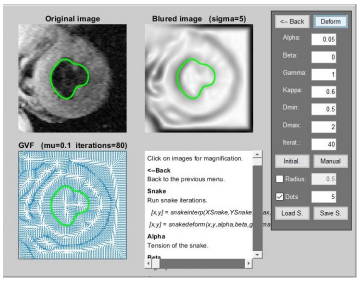

Fig. 15. GVF with 40 iterations with sigma=5

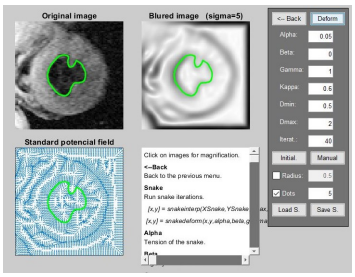

Fig. 16. Classical snake with 40 iterations with sigma=5

7. EXERCISE 6

Based on the experiment performed we found few problems associated with snake segmentation like - there are problem associated with initialization and poor convergence convergence to boundary concavities. Even though there are few problems associated with snake segmentation it is one of the best method to provide convergence or segmentation.
The two methods can be combined to get better results. First we do segmentation with classical snake after which we perform GVF on the resultant image. This way it will provide better results. We test this theory on the data *room.pgm*, we perform classical snake on it to get figure 17 and then without changing the initialization we perform GVF on it to get better convergence which is shown in figure 18.

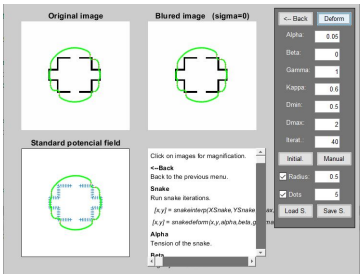

Fig. 17. classical snake with 40 iterations

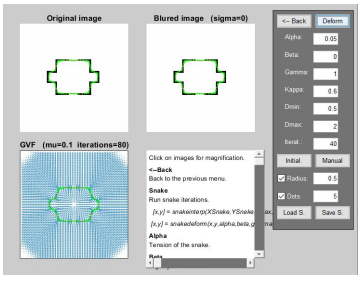

Fig. 18. Performing GVF after classical snake

8. REFERENCES

[1] C. Xu and J. L. Prince, "Snakes, shapes, and gradient vector flow," *IEEE Transactions on image processing*, vol. 7, no. 3, pp. 359–369, 1998.