Evolutionary Approach Based on Active Edges Detection for Images Segmentation

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Abstract—There are many methods for segmentation which vary strongly in their approach to the problem of image segmentation. In this paper, we specified the study in a particular segmentation method of radiological images based on the active edges detection. The optimize solutions was chosen as the genetic algorithm optimization method, and to compare this formalism with other existing methods, we chose a greedy algorithm is criterion for its timeliness. We propose a method of genetic active edge detection in images gray level. In fact, for the convergence of the edge to the object edges, we use the classic and the greedy method. Indeed, the proposed method is based on the active edges optimization using the genetic algorithms process to minimize a sum various energies, in order to evolve a population of snakes to an individual who has the minimum energy.

Keywords: Active edge, genetic algorithm, greedy algorithm, segmentation, medical image.

I. INTRODUCTION

Image processing is becoming omnipresent on internet, cinema, television, telephones, in the medical field, the picture is everywhere. Today it is no longer only process images to improve but also to understand and interpret. It is in this context that the recognition of objects in images becomes an important research topic. To recognize objects and to interpret the images, it is often the first segment, The field that interests us particularly is that of medical imaging, image sources are diverse. There are many methods for segmentation which vary strongly in their approach to the problem of image segmentation. Our work is based on the Roussele reference [1], when, we are interested to the method of active edges [2]. This is a particular method of segmentation and the optimize solutions was chosen as the genetic algorithm optimization method [4], and to compare this method with other existing methods, we chose a greedy algorithm is criterion for its timeliness.

Genetic active edges (GAE) is method of segmentation which is a model of active edges combined with a procedure for energy minimization based on genetic algorithms.

Indeed, this method is proposed to solve the conventional limits of active edges, such as initialization, the existence of multiple minima and selection of elasticity parameters.

In this paper, we propose a method of active edge detection in images gray level and the convergence of the edge to the object edge of the classic and greedy method, is based on the active edges optimization using the genetic algorithms process.

II. GREEDY ALGORITHMTS

A greedy algorithm proposed by Williams and Shah [3], is an algorithm that follows the principle of making step by step, a local optimum choice in the hope of obtaining a global optimum result.

A. Active Edges

In the problem of active edges based on minimize the energy, the algorithm consist in repeating the choice of edge smaller energy where the algorithm does not systematically provide the optimal solution, it is called a greedy heuristic.

The process of algorithm is iterative, it examines at each iteration, the neighborhood of each point of snake[1]. Thereafter, the process of the algorithm chooses the point of the neighborhood that gives the lowest value of the global energy.

B. Process Greedy Algorithm

The process greedy algorithm will be in five stages: initialization of edge, determine the neighborhood, calculate the energy, normalization and minimization energy, in the last, calculate the stability of the snake by stopping criterion.

- Stage 1: The initialize of the edge by a set of points ie. boss points.
- Stage 2: Select the neighborhood for each point of snake.
- Stage 3: Calculate the energy for each neighborhood found in the previous stage, then calculate the global energy.
- Stage 4: Normalize the various expression members of the global energy before minimization.
- Stage 5: The stabilize of the snake by stopping criterion.

In fact, the energy continuity and the energy curvature are normalized by dividing by the value of the maximum in the neighborhood, thus providing a value within the interval [0,1]. The value of the external energy ie. energy image (val) is normalized on the neighborhood given by: (min-val)/(max-min).

Where max and min: are the maximum energy and the minimum energy.
To avoid excessive gradient, if \((\text{max-min})<5\), then \(\text{min}\) will be put to the value five.

- Stage 5: The stopping criterion is the stability of the snake points represented by percent.

III. GENETIC ALGORITHM FOR ACTIVE EDGES

From the literature GAE, Ballerini [5] proposes a segmentation method with the use of genetic active edges (genetic snakes), which is a model of active edges combined to an energy minimization procedure based on GAs.

The GAEs are proposed to address some limitations of classical active edges (AE), such as initialization, existence of multiple minima, and the selection of elasticity parameters. Ballerini has extended the formulation of GAE in two ways, by:
- Exploring additional internal term,
- The corresponding to the external energy term.

IV. GAE DETECTION FOR MEDICAL IMAGES (GAED-MI)

We describe in our solution the decomposition process of the medical images segmentation by the active edge method using the process optimization of genetics algorithm.

There are three choice segmentation by conventional method, the greedy algorithm and the GAED-MI method.

The overall architecture of GAED-MI is illustrated in the following figure:

![Fig. 1. Overall system of GAED-MIs](image)

The algorithm of GAED-MIs is divided into four main phases.

**Algorithm GAED-MIs**

**Input**: medical image (gray level image).

**Output**: segmented image.

**Begin**
- Initialize the edge();
- Preprocessing phase();
- Segmentation by classic methods();
- Segmentation by GAED-MI method();
- Segmentation by Greedy algorithm();

**End.**

We can detailed the behavior phases of GAED-MIs system by:

A. Preprocessing Phase

It is the pretreatment before segmentation to improve the image quality and noise destroyed, this phase results gives a filtered image.

There are several smoothing filters as we specify in our system the most important:

1) **Filter Contrast**

The purpose of applying a contrast filter is making the edges more visible. This is done by a convolution product between the image and the following matrix:

\[
\begin{pmatrix}
0 & -1 & 0 \\
-1 & 5 & -1 \\
0 & -1 & 0
\end{pmatrix}
\]

For all:

\(l_i, j\) of image \(1\):

\[l_i-1, j, j-1, i-1+5l_i, j-1, i+1-l_i, j \]

2) **Smoothing operation**

There are several filters for smoothing the image, they can reduce the amplitude of disturbances that degrade image quality. We chose the use of Gaussian filter.

3) **Filter Gaussian**

The image is multiplied by a Gaussian mask with three or five dimensions.

\[
\frac{1}{16} \begin{pmatrix}
1 & 2 & 1 \\
2 & 4 & 2 \\
1 & 2 & 1
\end{pmatrix}
\]

For a Gaussian filter, the smoothing operation is as follows:

For Point \(i, j\) of the image \(I\):

\[
\left[\begin{array}{c}
2*\text{Pixel}_{i-1, j-1} + 4*\text{Pixel}_{i, j-1} + 2*\text{Pixel}_{i+1, j-1} \\
2*\text{Pixel}_{i-1, j+1} + 4*\text{Pixel}_{i, j+1} + 2*\text{Pixel}_{i+1, j+1}
\end{array}\right] / 16
\]

B. Segmentation by classic methods

Operators Sobel, Prewitt and Robert are gradient operators, i.e. the first derivative. For obtain the gradient of an image, we calculate the value of each pixel of the image according to its weighted neighborhood by a coefficient matrix determined.

\[
\begin{pmatrix}
1 & 0 & 0 \\
0 & -1 & 0
\end{pmatrix} = \begin{pmatrix}
1 & 1 & 1 & 0 & -1 \\
0 & 0 & 0 & 1 & -1 \\
-1 & -1 & 1 & 0 & -1
\end{pmatrix}
\]

Robert matrix

\[
\begin{pmatrix}
1 & 2 & 1 & 0 & -1 \\
0 & 0 & 0 & 2 & 0 & -2 \\
-1 & -2 & -1 & 1 & 0 & -1
\end{pmatrix}
\]

Sobel matrix
Canny detector: The team of John Canny [6] began by giving a more precise definition of what the edge in an image and therefore what should be an algorithm for edge detection.

- The edge detection algorithm must detect only the edges. It should detect all edges and not forget any one;
- The distance between the detected edge and its actual position should be as low as possible;
- It does not detect multiple edges, where there is only one.

C. Segmentation by GAED-MIs method

The principle of genetic algorithm is to encode each potential solution to our problem by a chromosome (individuals), the set of chromosomes forms a population. Individuals is a set of points which build the snake, so we made changes in a population of snakes. Single best snake of the population at the approximation of the edge.

1) Initialization

The first step of genetic algorithm is the construction of an initial population, a set of chromosome representing edges.

- A lack of sense of integration between snakes, these random points does not give a sense of edges (see Fig. 3).
- The edge is not in conditions of classical initialization where the points already form a closed edge.

- Resolution problem: To solve this problem we proposed the following resolution steps:

  - First step: we suggests that the snake was placed around the form to detect. And the number of snake points (boss points) will be constant until reaching the desired convergence (see figure below), and initializing the user can easily obtain the coordinates of snake.

  - Second step: we calculate the global energy for the neighborhood of each initial snake, And the neighbor who has the minimum energy will be the new point for the new snake. Repeats the calculated energy for the new snake to get another snake with the same procedure, and so after a number of iterations, the set of snakes is obtained representing the initial population.

After solving the problem of random initialization, it is now necessary that we specify the encoding type of the individuals initial population.

**Algorithm 2 GeneratingInitialPopulation**

```
Begin
For i =1 to n and j=1 to m do
  For each initial snake do
    For all the points of neighborhood do
      Calculate_energy();
    Endfor;
    Population(i,j)= Add_min();
  Endfor;
Endfor;
End.
```

Where n: is the number of snake and m: is the population size.

**Calculate_energy():** This function calculates the global energy for each neighborhood of snake. It is defined by:
\[ E = \alpha E_{\text{continuity}} + \beta E_{\text{curvature}} + \gamma E_{\text{gradient}} \]

\[ \alpha, \beta, \gamma : \text{are constant coefficients.} \]

After calculating the global energy for each neighborhood snake. We add the neighbor who has the minimum global energy to the matrix population by the function Add_min().

2) **Individuals coding**

The individual coding is how the physical reality of the snake. The edge is a set of points, the intuitive coding consist in concatenating the cartesian coordinates of each point. There are several types of coding and in our application areas, the optimization problems has real variables, so we use the real coding.

The figure below illustrates the representation of the individual.

![Encoded edge in cartesian coordinates](image)

3) **Evaluation**

The initial population is evaluated by an objective function, called fitness or evaluation function of the individual. For the defined problem the function to calculate the total (global) energy for each individual [1]:

\[ E_{\text{continuity}}(M_i) = \text{dis} \tan^{\text{ce} \text{average}} - \sqrt{(x_i - x_{i-1})^2 + (y_i - y_{i-1})^2} \]

where Average_Distance is the average distance between two successive points of the active edge.

\[ E_{\text{curvature}}(M_i) = \sqrt{(x_{i-1} - 2x_i + x_{i+1})^2 + (y_{i-1} - 2y_i + y_{i+1})^2} \]

\[ E_{\text{gradient}} \] is estimated based on the Sobel gradient.

4) **Selection**

The selection operator gives more opportunity to the good people to participate in the next generation, according to fitness. Several methods of selection are possible, we limited our study to rank selection methods that provides an increasing order of individuals from the individuals has minimum energy to the individual who has the maximum energy.

In fact, in our work we chose the stronger half of the individuals.

**Algorithm 4 SelectionRank**

Begin

For i=1 to m do

\[ \text{Calculate}_\text{fitness}(); \]

Endfor;

\[ \text{Order}_\text{individuals}(); \]

For i=1 to n and j=1 to (m/2) do

\[ \text{Half}_\text{population}(i,j)=\text{Select}(); \]

Endfor;

End.

5) **The crossover and mutation operator**

The objective of the crossover operator is to combine chromosomes hoped for parents with qualities of better individuals. Crossing is to mix in the genome, genes of two parent individuals to generate two children, the population size remains constant court optimization process.

The experiment shows that the choice of a method of crossing little effect on the quality of the final solution. However, it has a strong influence on the speed of convergence of the algorithm, so we selected the multiple crossing.

The mutation overcomes the lack of diversity of the initial population.

6) **Replacement**

After crossover and mutation a new generation is built keeping only individuals who have a very high value of adaptation that allows to accelerate the convergence to an optimal solution quickly.

**D. Segmentation by the Greedy algorithm**

The greedy algorithm is an iterative algorithm. At each iteration, we seek improvement by changing a single point which is replaced by a better point, this change allows to
decrease the global energy. The global energy contains $N$ terms but only one is considered. The $N-1$ points that have not been moved and the new point is then the approximation of a new edge. All points are treated in succession along the edge.

This code allows to present the steps of the greedy algorithm [1]:

**Algorithm 5 Greedy**

**Begin**

Repeat

For all snakes do

For all points in the neighborhood do

Calculate the energy();

Endfor;

For all points in the neighborhood do

Normalization();

Endfor;

Minimization();

Endfor;

Until stopping criterion 2.

**End.**

V. EXPERIMENTAL RESULTS

This section is devoted to present synthetic results application (see Figs. 8, 10, 11 and 12) of GAED-MIs method compared to Canny edge detector [6]. These following experiments are performed by using MATLAB on a Core Due, CPU 2.00 GHz with 3,00 GB.

![Fig. 6. Behavior of the Greedy algorithm.](image6)

![Fig. 7. The system process of Greedy algorithm.](image7)

![Fig. 8. Segmentation Condyle image (323x420 pixels) by Greedy method.](image8)
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In fact, the results of segmentation by existing methods on synthetic and real images can distinguish that the traditional methods give poor results and non-dynamic edge. We can see that, the Greedy method is faster compared to the GAED-MIs method. The genetic algorithm with its principle advantage optimization solutions enables to give more data effective results and one of the drawbacks of the greedy method that it solve by the genetic algorithm this is the convergence of all points.

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VI. CONCLUSION
In the context of image processing we are interested in the method of segmentation by active edge of greedy implementations.

It is, in any case, the minimization of a sum of various energies, we have proposed for this minimization problem, using the genetic algorithm, this study uses the GA in order to evolve a population of snakes to an individual who has the
minimum energy, we presented the different operators of GA which has specified this optimization problem by detection mechanism of genetic active edges GAED-MIs.

We made various tested and the results obtained are compared with more conventional method and the results given by the process of the greedy algorithm in particular. We tested the effectiveness of our method for detecting active edge in gray level images. The convergence edge to the object edge does by conventional edges of classic methods, the greedy algorithm based on active edge using optimization process of genetic algorithm.

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