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Level Set method for breast regions detection

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Abstract. The cancer treatment is currently effective only if it is detected at an early stage. In this state, Mammography is the most efficient method for early detection. In addition, CADx systems (Computer Aided Diagnosis) and CAD systems (Computer Aided Detection) are important to reduce breast cancer mortality. In this context, Segmentation of region of interest (ROIs) is a most important step in these systems. This paper proposes a method for ROI segmentation in mammographic image based on front propagation. This approach consists in making evolve/move a initial curve (a point) which converges towards the borders. In this approach two different algorithms are used to ameliorate the Level Set implementation in term of temporal complexity: Narrow Band and Fast Marching algorithms. This paper describes a work in progress. We show via this work, visually results, the effectiveness of level set uses in the context of ROI segmentation quality.

Keywords: Geodesic Active Contour, Mammography, Level Set, segmentation, ROI

Résumé : Le traitement de cancer est efficace seulement s'il est détecté à un stade précoce. Dans ce cadre la mammographie est la méthode la plus favorisée. En plus les systèmes d'aide à la détection et au diagnostic peuvent jouer un rôle très important dans la procédure de l'examen médicale. Dans ce cadre l'étape de segmentation est une étape essentielle dans la conception de ces systèmes. Dans ce papier, nous proposons une méthode d'extraction des régions d'intérêts (ROIs) dans une image mammographique. Cette approche consiste à faire évoluer une courbe initiale (un point) qui converge vers les frontières des ROIs. Dans cette approche, dans la partie implémentation des courbes de niveau (Level Set), on a utilisé des algorithmes rapides comme la bande étroite (Narraw Band) et celle de progression rapide (Fast Marching). Ce travail décrit un travail en progression. A travers ce travail nous donnons, via des résultats de visualisation, l'efficacité et la qualité de l'utilisation des courbes de niveaux dans le contexte de segmentation des ROIs.

Mots Clés: Contour actif géodésique, Mammographie, Courbe de niveau, segmentation, région d'intérêt.

1- Introduction

Breast cancer is considered as a major health problem and constitutes the most common mortality that causes cancer among women in the world. However, although breast cancer incidence has increased over the last decade, breast cancer mortality has declined among women of all ages [1]. This favorable trend in mortality reduction may relate to improvements made in the breast cancer treatment and the widespread adoption of mammography screening. In the past decade many research efforts attempts to a generalization of approaches used in general imaging processing to cope with specific one; namely, medical image processing or analysis. In the past several years there has been tremendous evolution in mammography process. In addition, systems CADx (Computer Aided Diagnosis) and CAD (Computer Aided Detection) mammography might complete or substitute to "human" double reading [2]. In addition, image segmentation as well as the boundary detection is critical problem of early vision and they have been widely studied in particularly in medical imaging. In this paper, we are interesting for a special application of mammographic image. In fact, identification of breast region is important to analysis region in benignant and malignant ones. In this context, Liu et al [3] used a multiresolution approach to detection speculated region in mammographic images. Varel et al [4] investigated the behavior an iris filter at different scales. After applying an iris filter, suspicious regions were segmented by means of an adaptive threshold. Rabottino et al [5] implemented an algorithm based on region-growing technique.

Recently, explicitly and implicitly methods of deformable model are used in different applications [6]. In this context, in breast cancer detection, Ferrari et al [7] used a traditional active deformable contour model to limit the breast in the other of image. To injure the problem of initialisation they used an adaptatif seuillage. For elimination the pectoral muscle, Boucher et al [9] used the snake and Ball et al [10] used the Narrow Band level set methodology with an adaptative segmentation threshold controlled by a border complexity term.

In contrast to explicit models, Level set approach use a dense contour: the implicit evolution avoids the needs to track surface markers in relation to each other.

On the basis of this state of the art, we include the method of segmentation ROIs based in geodesic active contours [8] implemented in Levels Set approach. To minimize it temporal complexity, the amelioration is obtained by adaptation the Narrow Band and Fast Marching method in implementation. Hence, the performance is illustrated in two points of view: precision of segmentation ROI in diagnostic relevance and computation time of optimization.

The rest of this paper is organized as follows: section 2 describes the proposed scheme. Section 3 illustrates the Level Set approach adopted in segmentation. Section 4 presents the results obtained by the proposed scheme. Finally, we draw conclusions and some future issues in section 5.

2- The flow proposed in detecting breast cancer

The proposed scheme consists of three stages: identification of ROI, features extraction and vector classification. Figure 1 shows the bloc diagram of the proposed scheme. A method of segmentation based on Level Set approach is adopted which is the stage of flow in which we are interest in this paper. After the isolation of the ROI, extraction of features is adopted. After that a classification part is started. The features vector is entered to the classifier to make decision.

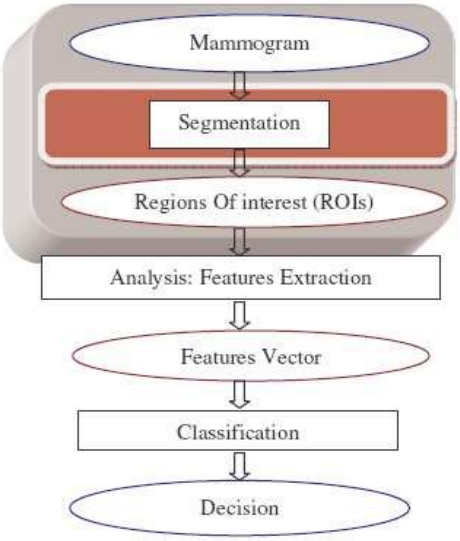

***Figure 1**: Proposed Flow*

In the next section, we will illustrate the method of segmentation adopted in this paper.

3- Method: implementation Geodesic active contour in Level set approach

Level Set is a method which studied evolution of the curve and surfaces [12]. The points defining this interface will move towards the normal at a speed F according to the following equation:

$$\frac{\partial C}{\partial t} = F\vec{N} \qquad (1)$$

N: normal with the curve

F: speed term depending on the curve

The parametric curve C(T) is recovered by the detection of the level zero of ν , respectively, the function F evolves and moves according to:

$$\frac{\partial \phi}{\partial t} = F\left|\nabla \phi\right| \qquad (2)$$

Evolution of this function depend an initial curve . In this case two aspect of research: initialization and the function F. In this paper, the initialization is adopted with a point centered of region to be detected. In the other hand, speed F is decomposed in three terms: terms depend on the local curve in each point (pondered with ε), term dependent on the image (pondered with β) and a constant term (pondered withν). The evolution of interface is given by the following equation:

$$\frac{\partial \phi}{\partial t} = \varepsilon * g(I)\left|\nabla \phi\right| div\left(\frac{\nabla \phi}{\left|\nabla \phi\right|}\right) - \beta * \nabla g(I).\left|\nabla \phi\right| + \nu * g(I)\left|\nabla \phi\right| \qquad (3)$$

where

- ε, β, ν ∈ [0,1]
- I : image Matrix
- $g(I) = \frac{1}{1+\left|\nabla I(x,y)\right|}$ where $\left|\nabla I(x,y)\right| = \left((I(x+1,y)-I(x,y))^2 + (I(x,y+1)-I(x,y))^2\right)^{1/2}$

- $$|\nabla\phi_i| = \left(\left(\max(D_x^-\phi_i,0)\right)^2 + \left(\min(D_x^+\phi_i,0)\right)^2\right)^{1/2} \quad \text{where} \quad D_x^-\phi_i = \frac{\phi_i - \phi_{i-1}}{\Delta x} \quad \text{and} \quad D_x^+\phi_i = \frac{\phi_{i+1} - \phi_i}{\Delta x}$$

Narrow band: consist of computing Level Set on evolution from contour for early inside and outside near the Level Set zero [11]. We use this approach from two reasons: Firstly, to optimize time computation efficiency for numerical calculus Level set method. Secondly, regions in breast are difficultly detected from globally image. In fact, we should focus locally more on the zero Level Set and it's neighboring Level Set because locally contour has more information significance than distant ones.

Fast Marching: In Level set approach, the function F is negative or positive depending with minimal distance between every point in an image (in our case the narrow band) and the initial front. In fact, we then have a monotonically advancing from front which accelerating the convergence [11].

In this paper we adapted the Geodesic active contour in Level set algorithm proposed with Sethian [13] in the narrow band approach. The result is presented as follows: First, we tag points in the initial conditions as Alive (in our case we used a point for initialization, after the first iteration, this point propagate and can construct a closed curve). We then tag as Close all points' one grid point Away. Finally, we tag as Far all other grid points. Then the loop is:

1. Begin Loop: Let Trial be the point in Close with the smallest value for Δ.
2. Add the point Trial to Alive; remove it from Close
3. Tag as Close all neighbors of Trial that are not Alive. If the neighbor is in Far remove it from that list and add it to the set Close.
4. Recompute the values of Δ at all neighbors according to equation (3) by solving the quadratic equation, only using values for points that are Alive.
5. Return to top of Loop;

Implementation of surface evolution using equation (3) calls upon the approximations in finite differences in first order (in our case 2D).

In this section, we detailed the implementation method based on geodesic active contours in Levels Set approach. To minimize this temporal complexity, we adopted Narrow Band and Fast Marching method in implementation. In the next section, we will illustrate the result of segmentation adopted in this paper.

4- Results and discussion

Any result obtained from segmentation procedure was illustrated below. Figure 2 shows several example cases. In this figure, each row corresponds to one case. In every raw we have respectively, originally image in DDSM database detoured by a radiologic (red line), originally image without contour, image segmented in the context of this approach (red line) and region isolated ROI. However, it is clearly that our segmentation results is quite close than the manually segmentation results obtained by the radiologist. So, remain to see the quality of the segmentation who could be proven by the analysis step. Moreover, breast tumors and masses appear in mammograms with different shape characteristics: malignant tumors usually have rough, microlobulated, or spiculated contours; whereas benign masses commonly have smooth, round, macrolobulated, or oval contours. In this context, the method can reflect the irregularity or regularity of region more precisely comparing with manually process.

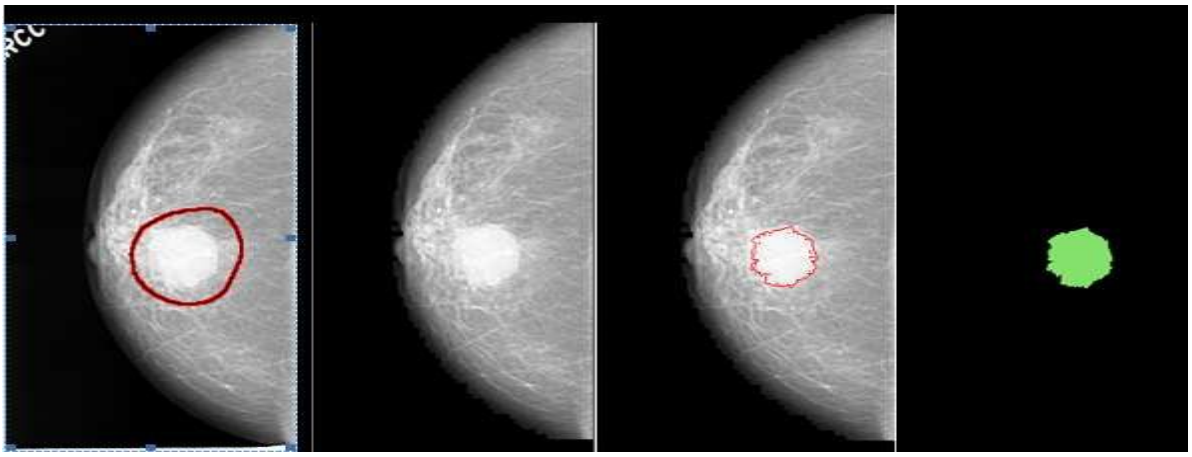

Figure 2 (a) : *mammogram Left Craniocaudal (CC), patient age=60*

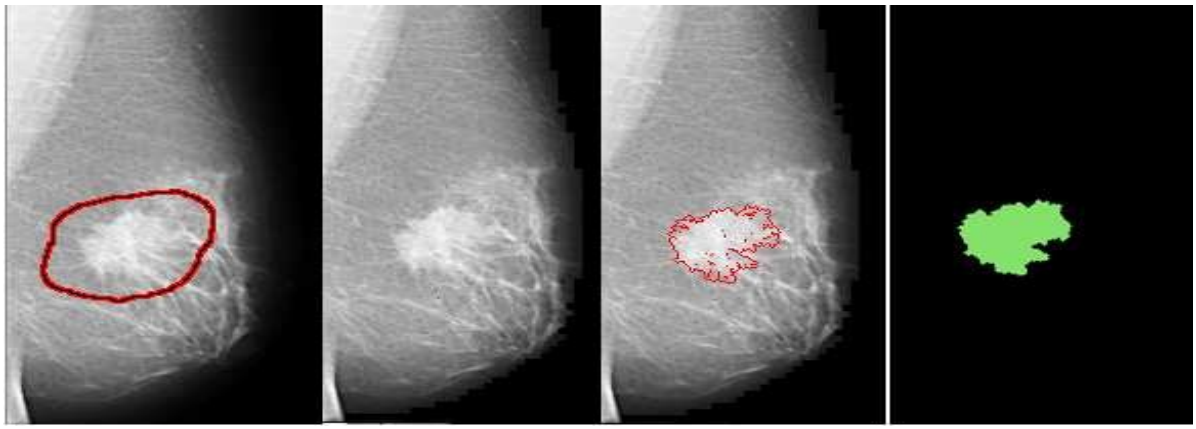

Figure 2 (b) : *mammogram Right Mediolateral oblique (MLO), patient age=60*

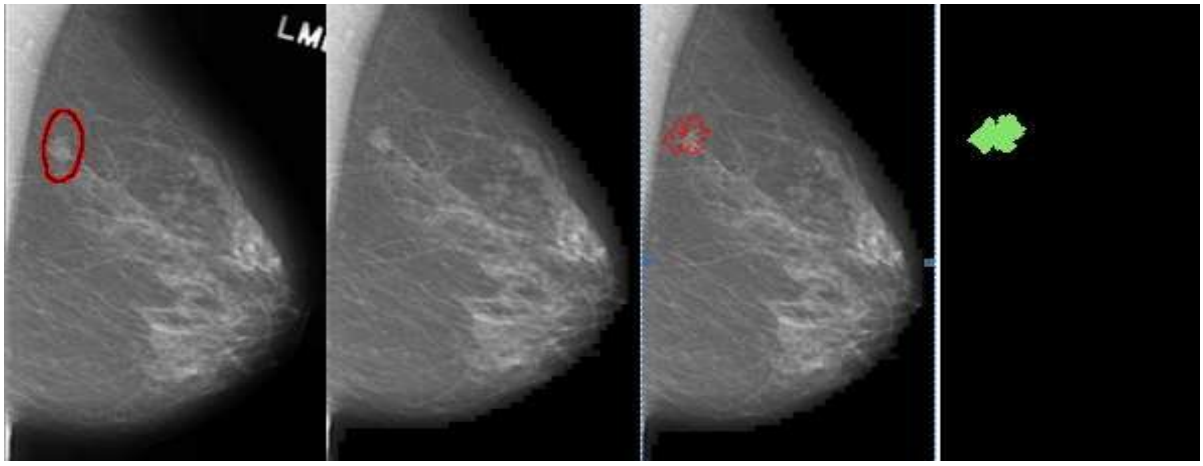

Figure 2 : *mammogram images; showing from left to right : originally image in DDSM database detoured by a experimented radiologic (red line), originally image without contour, image segmented in this approach (red line) and region isolated ROI in three cases (a) : mammogram Left CC, patient age=60, (b): mammogram Right MLO , patient age=60 and (c) : mammogram Right MLO, patient age=70*

5- Conclusion

In this work, we attempted to improve result of segmentation ROIs with method based in Level Set approach in mammographic images. The performance is illustrated in two points of view; precision of segmentation ROI close than the manually segmentation results obtained by the radiologist and computation time of optimization by using Narrow Band and Fast Marching method in implementation. The result can be ameliorating by using a region characteristic in Level Set criteria. After that, methods of analysis based in features extraction can be adopted in ROI followed a classification part to make decision.

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