# Mass Edge Detection in Mammography Based on Plane Fitting and Dynamic Programming


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## ABSTRACT
In this paper an automatic and effective method was proposed for mass segmentation in mammography. Based on the facts that mass edges are continuous and closed curves consisted of points which have larger gradient transformation, a plane fitting method and a dynamic programming technique were applied. The regions of interest (ROIs) used in this study were extracted from DDSM. The preliminary experimental results show that the segmentation algorithm performs well for various types of masses.



## Categories and Subject Descriptors
I.2.10 [**Artificial Intelligence**]: *Vision and Scene Understanding, Learning.*

I.5.4 [**Pattern Recognition**]: *Computer Vision.*

## General Terms
Algorithms, Measurement, Experimentation

## Keywords
Mammographic mass segmentation, plane fitting, dynamic programming, edge detection


## 1. INTRODUCTION
Breast cancer is one of the major causes of death in women over age 50 [1, 2]. Scientific evidence indicates that early diagnosis and treatment of breast cancer can reduce mortality and morbidity of patients [3, 4].

Mammographic mass segmentation is an important step in CAD systems. But due to the complex features of the abnormalities, it is difficult to apply an adaptive method to segment them. In recent years, many studies [5, 6, 7, 8] have been focused on the mammography segmentation.

In this paper, a new algorithm with an automatic search for mass lesions contours in mammography was described. First, the new method uses a plane fitting technique to determine the edge candidate points which have larger gradient transformation. Secondly, based on the edge candidate points, a best contour is obtained by using the dynamic programming technique.

## 2. ROI PREPROCESSING
The center of ROI was calculated with an iterative procedure based on the center of mass boundary marked by radiologists. Due to the low contrast of the abnormalities, the least square plane fitting method was used to correct the background trend of the original ROI. In order to improve the contrast of the mass, a Gamma correction procedure and a simple Gaussian filter were used sequentially. We defined the final result as the background-trend corrected ROI.

## 3. EDGE CANDIDATE POINTS
A local plane fitting method at each pixel was carried out. We define the fitting plane as $P$.

$$P = a \cdot i + b \cdot j + c \qquad (1)$$

From equation (1), we can deduce the top-down gradient transformation on the vertical direction is a, while the left-right gradient transformation on the horizontal direction is b.

According to a discretionary pixel A, the vertical gradient value is a, while the horizontal gradient value is b. The module of the vector on the direction which is from pixel A to the center of ROI is described as t. The angle determined between vector t and the left-right horizontal line is $\theta$. Based on these definitions, we can get equation (2).

$$\frac{\partial P}{\partial t} = -a \sin\theta + b \cos\theta \qquad (2)$$

We define a parameter "d" as $-a\sin\theta + b\cos\theta$. Parameter "d" indicates the gradient transformation on each direction pointed to the center of ROI which is calculated with the vertical and horizontal gradient. Based on the gray scale image according to parameter "d", top five largest values on each radial line (straight lines pointing outward from the center of a ROI with a fixed angle such as 45 degree between two adjacent radial lines) were extracted. These points on all radial lines were the edge candidate points which will be used in the next stage.

## 4. DYNAMIC PROGRAMMING

A dynamic programming (DP) technique which has been applied on pulmonary nodule segmentation [9] was used to determine the optimal boundary for an abnormality from the edge candidate points. The cumulative cost function $C$ for a boundary including 64 points, one point at one radial line, is defined as the sum of local costs. The local cost at each point is defined by the local cost function. The local cost function consists of an internal cost function and an external cost function.

More detailed descriptions can be found in the literature [9].

In the dynamic programming procedure, if there are no edge candidate points, we would interpolate points on the current radial line based on the edge candidate points at the previous radial line.

## 5. EXPERIMENTAL RESULTS

Study cases for this work were chosen from DDSM [10]. The raw data images were firstly sub-sampled and transferred to 8-bit gray values. Regions of interest with 125×125 pixels size based on the calculated mass center were extracted from the sub-sampled and gray scale transferred images. Figure 1 show outlines marked by radiologists and segmentation results generated by our method for schematic ROIs.

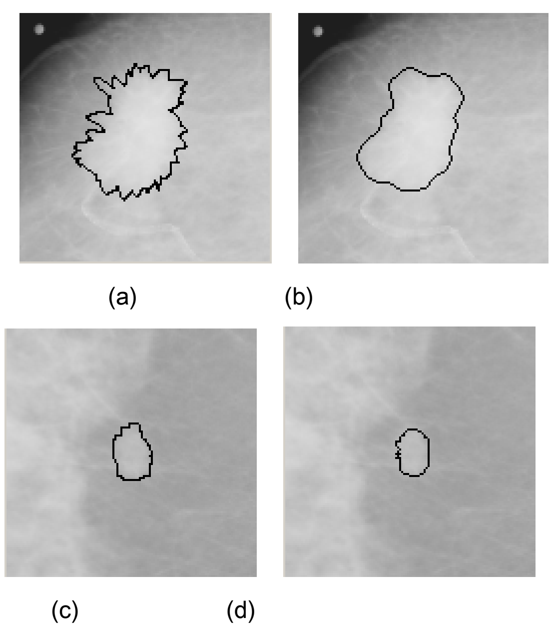


**Figure 1. (a) outline marked by radiologists. (b) result generated by our segmentation method. (c) outline marked by radiologists. (d) result generated by our segmentation method.**

## 6. CONCLUSIONS

This paper proposes an automatic and effective method for mass segmentation in mammography. A plane fitting method and a dynamic programming technique were sequentially used to find the optimal contour of the mass. The preliminary experiment results show that the segmentation algorithm performs well for various types of masses. Further experiments on this segmentation algorithm and comparisons with other segmentation algorithms are the next step in this project.

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