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Boundary Detection in Medical Images Using Bonding Box Based Contour Method

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Abstract
Medical images can be identified with the help of their proper boundaries. Boundary provides clarity to medical expert in understanding any view and also it helps in further medical analysis. Boundary detection plays a major role in Medical field, as finding the correct boundary in noisy images is still a difficult task. This paper introduces the new technique of detection using the information of intensity and texture of an image using the information from the intensity gradient via the vector image model and the texture gradient via the edge map. We discuss the proposed technique on various medical images provides correct boundaries even in an ill-defined images and multi grey level images. This method is robust and applicable on various kinds of noisy images without prior knowledge of noise properties.

Keywords Boundary Extraction, Edge Following, Edge Map.
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Introduction

Image segmentation is an important step before performing high level tasks. While considering the case of a brain tumor patient, the MRI scan of his brain shows the tumor but not clearly. If the boundaries of tumor are detected then its size can be calculated and further medication can be planned. So in order to find the boundary we need to understand the basic image processing step [1] i. e., segmentation. Segmentation partitions an input image into its constituent parts or objects. Edges are nothing but local changes in the image intensity and these occur on the boundary between two regions. The changes due to shading are not edges. Output of segmentation is usually raw pixel data constituting either boundary of a region or all points in that region. Segmentation algorithms are generally based on two properties of grey level values, discontinuity and similarity. First one is based on abrupt changes in grey levels usually detects lines and edges. Second one is based on thresholding, region splitting and merging. So many edge based algorithms as Sobel, Prewitt, Laplacian and region based approaches as region growing, merging, clustering have been implemented. However the performance evaluation of image segmentation results is still a challenging problem as they fail to extract the correct boundaries of objects in noisy images.

In recent years, among the several new methods like active contour model (ACM), gradient vector flow (GVF), geodesic active contour (GAC) model, active contours without edges (ACWE) etc. The snake models have become very popular especially in boundary detection. The ACMs is one of the snakes are curves that can be moved under the influence of the external energy and internal [2]. The internal energy keeps the model smooth during deformation. The external energy moves the model toward an object boundary. But the snake has the limitations of small capture range and difficult into concave boundary regions. The GAC model is an extension of the ACM methods which are based on curve evolution and level sets but the boundaries are not defined by gradient [3]. To address this problem, we propose a new technique for boundary detection for ill-defined edges in noisy images using an improved edge following technique based on the vector image model and the edge map. The vector image model provides a complete description of an image by considering both directions and magnitudes of image edges. From the vector image model, a derivative-based edge operator is applied to yield the edge field [4].

Boundary can be detected in a noisy image by the above mentioned algorithms but most of the algorithms have difficulties in detecting boundaries in images with ill-defined edges [5]. In many medical images like in scanned images of lungs and brain, the accumulations of organs with blockages or damages cannot be figured out correctly as they are too complex and noisy[6]. As a remedy to this problem, we propose the technique of edge following method based on the intensity and texture values of the image. Intensity refers to the brightness of a point in an image and is determined by several quantities including the local concentration, the quantum efficiency of the fluorophore and sensitivity of the light sensor in the imaging system. Texture gives us information about the spatial arrangement of color or intensities in an image or selected region of an image and this is one way that can be used for segmentation [7]. The intensity gradient is defined as the directional change in the color value of an image. Since the intensity function of a digital image is only known at discrete points, derivative of this function is considered usually. A complete description of an image we consider both directions and magnitudes of image edges as vector image model. The vector image model, a derivative based edge operator [8] is applied to get the edge vector field which is obtained by averaging magnitudes and directions in the vector image. Number of methods [9] has been proposed, one of the best techniques is edge map which is derived from law's texture and the canny edge detection. The vector image model and edge map are applied to select the best edges.

Krit Somkath in [10] has introduced a technique to overcome the problem of boundary detection for ill defined edges using edge following algorithm based on Intensity gradient and Texture gradient Features, but this has got limitation that the boundary must be closed

The process of boundary detection carried out using intensity gradient and texture gradient is useful and gives good results if the image has minimum range of gray values. If more variations in gray values is found in an image then it will be time consuming. Moreover the values of α, β *and* ε need to fed manually for every image which makes it more time consuming, hence an automatic method is required in simple implementation of boundary etection

The paper is organized as follows. Section II and III describes the boundary detection using vector image model and edge map. Section IV, Section IV Experimental results and Section V concludes the paper.

Boundary Detection Algorithm

Medical images are enriched with specific textural patterns. These patterns have specific information. Medical images have poor boundaries [11]. A boundary is a line that marks the limits or edges of an entity and separates it from the background. It helps us in Object recognition and understanding the shape of an entity. Low resolution, several scanning devices are used, blurring effect and contrast results difficulty in identifying the tissue patterns and structure of organs and these are some causes of reduction in the retrieval output.

Medical images consist of many objects which can be identified with the help of proper boundaries [12]. In this approach, the boundary of the query image and data base images are detected using edge following algorithm which provides complete information of an image by considering both magnitudes, directions and of image edges using vector image model to which derivative-based edge operator is applied to yield the edge field [13]. The proposed algorithm consists of four phases

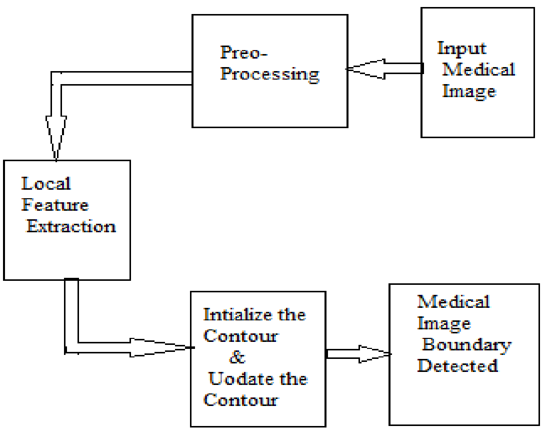


Fig (1) Block Diagram of the Proposed Method

Phase1: In our proposed method we consider the MRI scan of brain tumor image is consider as input medical noisy image which is not having clear boundaries.

Phase2: Generally the medical images are corrupted with noise due to some scanning devices and the improper lenses setting and poor illumination. To avoid all the defects from the medical image we need to undergo pre-processing by using median filter.

Phase3: The local features of an input image are extracted for further processing. A gradient feature of an image is considered as local features.

Phase4: The texture pattern in the medical image is strengthening by convolving with the texture map. Various texture mapping methods are described in the literature, among them we are adapted Gaussian texture mask which smoothen the medical image.

Phase5: Initialize the Bounding box with initial values.

Phase6: Extract the local features from the medical image using intensity gradient and texture map.

Phase7: Update the contour which links the edges present in the medical image with the help of local features of an image.

Phase8: Finally the boundary of the image is detected from the medical data.

A Local Feature Extraction

i) Various physical events cause intensity changes. –

- Geometric events like object boundary (discontinuity in depth and/or surface color and texture)
- surface boundary (discontinuity in surface orientation and/or surface color and texture)
- Non-geometric events like specularity (direct reflection of light, such as a mirror) and shadows (from other objects or from the same object), inter-reflection

ii) Edge descriptors

- Edge normal: unit vector in the direction of maximum intensity change.
- Edge direction: unit vector to perpendicular to the edge normal.
- Edge position or center: the image position at which the edge is located. Edge strength: related to the local image contrast along the normal.

iii) The various edge detection operator are given as

Sobel Operator

$$G_x = \frac{1}{4}\begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & -1 \end{bmatrix} \quad G_y = \frac{1}{4}\begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix}$$

Prewit Operator

$$G_x = \frac{1}{3}\begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}, \quad G_y = \begin{bmatrix} 1 & 1 & 1 \\ 0 & 0 & 0 \\ -1 & -1 & -1 \end{bmatrix}$$

Gradient Convolution Masks

a) Gradient Convolution Masks

$G_x = [-1, 1]$ computes edge point at (i+1/2, j+1/2)

$G_y = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$ computes edge point at (i+1/2, j)

b) 2x2 masks: edge point at (i+1/2, j+1/2)

$$G_x = \begin{bmatrix} -1 & 1 \\ -1 & 1 \end{bmatrix}, \; G_y = \begin{bmatrix} 1 & 1 \\ -1 & -1 \end{bmatrix}$$

c) edge points at center pixel (i, j) use 3x3 masks

$$G_x = \frac{1}{4}\begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}, \; G_y = \frac{1}{4}\begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix}$$

Laplacian Mask : The following mask approximates the Laplacian (both x, y)

$$\nabla^2 f[i,j] = \begin{bmatrix} 0 & 1 & 0 \\ 1 & -4 & 1 \\ 0 & 1 & 0 \end{bmatrix}$$

Given an image f(x, y), the edge vector field is calculated according to the following equations in x and y directions, respectively.

$$M(i,j) = \frac{1}{M_r} \sum_{(i,j)\in N} \sqrt{M^2{}_x(i,j) + M^2{}_y(i,j)} \quad (1)$$

$$D(i,j) = \frac{1}{M_r} \sum_{(i,j)\in N} \tan^{-1}\left(\frac{M_y(i,j)}{M_x(i,j)}\right) \quad (2)$$

$$M_x(i,j) = -G_y x f(x,j) \approx \frac{\partial f(x,y)}{\partial y} \quad (3)$$

$$M_y(i,j) = -G_x x f(x,j) \approx \frac{\partial f(x,y)}{\partial x} \quad (4)$$

Where G_x and G_y are difference mask of the Gaussian weighted image moment vector operator in the x and y directions where Mr is the total number of pixels in the 3x 3 window neighborhood N [14]. The idea exploited for the boundary extraction of objects in unclear images shown in the following figure (2).

B. Edge Map

Edges of objects in an image are derived from Law's texture followed by Canny edge detection. The texture feature of images is computed by convolving an input image F(x, y) with each of the texture mask T(x, y) which is defined as law's texture [15] and canny detection on the resultant image R(x, y).

$$T(x,y) = L.L^T \quad (5)$$

$$L = 1,4,6,4,1^{\,T} \quad (6)$$

$$R(x.y) = F(x,y) * T(x,y) \quad (7)$$

$$L_{ij}(r,c) = \alpha M_{ij}(r,c) + \beta D_{ij}(r,c) + \varepsilon E_{ij}(r,c)$$

$$0 \le r \le 2,\; 0 \le c \le 2 \quad (8)$$

where

$$M_{ij}(r,c) = \frac{M(i+r-1, j+c-1)}{Max_{i,j} M(i,j)}$$

$$D_{ij}(r,c) = 1 - \frac{|D(i,j) - D(i+r-1, j+c-1)|}{\pi}$$

$$E_{ij}(r,c) = E(i+r-1, j+c-1) \;;\; 0 \le r \le 2, 0 \le c \le 2$$

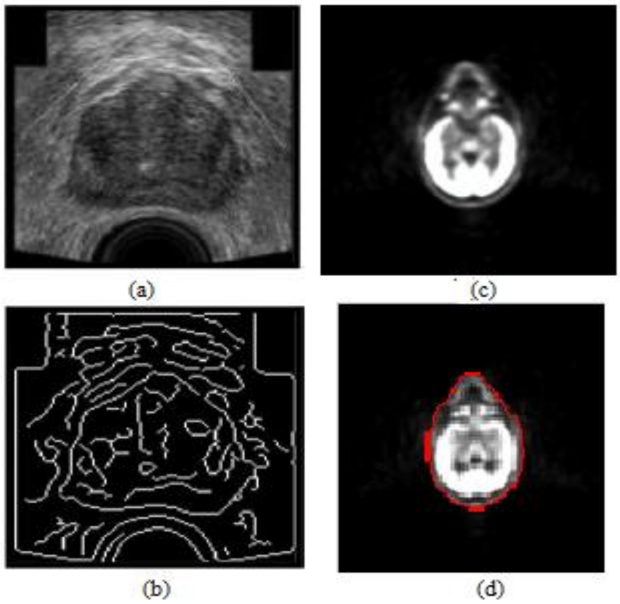


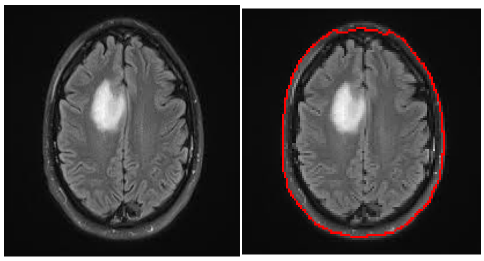
Fig. 2. (a) Prostate ultrasound image. (b) Corresponding edge maps derived from Law's texture and Canny Edge Operator (c) Brain image. (d) Boundary Detection

The four steps of edge detection

- Smoothing: suppress as much noise as possible, without destroying the true edges.
- Enhancement: apply a filter to enhance the quality of the edges in the image sharpening.
- Detection: determine which edge pixels should be discarded as noise and which should be retained by providing threshold criterion for detection
- Localization: determine the exact location of an edge (sub-pixel resolution might be required for some applications, that is, estimate the location of an edge to better than the spacing between pixels). Edge thinning and linking are usually required in this step.

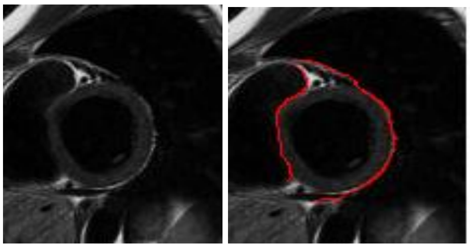
Experimental Results

We tested the performance of the proposed technique by considering many medical images. Some of the images are too noisy and some with ill-defined edges, But still the boundaries were detected by using the proposed method.



(a) (b)

Fig. 3 (a) Brain MR image (b) Boundary of brain is detected



(a) (b)

Fig. 4. (a) Aorta in cardiovascular MR image Original image (b) The boundary is detected by the proposed technique

Boundary Detection Algorithm Steps.

1. Read the image
2. Convolve image with Gaussian mask
3. Apply gradient %initial gradient
4. [u n]=Initializing the contour position
5. For 1: no of contours
6. [nx, ny]=gradient(u);%edge vector field convolution
7. Mx=sqrt(Nx^2+Ny^2);
8. Ang=angle(u);%end edge vector field%
9. [N]=gradient(nx, ny); % law texture. here we donot calculate convolution between image and mask. Because convolution applied in step 3
10. P=gradient(nx, ny);%edge detection.
11. E=N+P;%edge map=texture+ edge detection %end of edge map%
12. u=u+(Ω*Mx+α*E+β*ang); %edge following technique or contour update

Conclusion

In this paper, bonding box contour method combined gradients methods to achieve segmentation of medical images. Texture gradient and Edge map of pixels are selected as local features of medical images to separate the image from its background. Final segmentation result is obtained for brain MR images show that the proposed method is effective and promising for detecting the boundary efficiently.

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