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Edge Detection of MRI Images Using Morphological Operators

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Abstract-- In gray level images discontinuities in image intensity profiles is called edges. Detection of these discontinuities is essential steps in many machine vision tasks such as object recognition, motion analysis etc. In this paper, various morphological operators are used on MRI images and a new algorithm is applied to give better result.

Keywords-- Morphological operators, MRI images and threshold value.

I. INTRODUCTION

The word morphology commonly denotes a branch of biology that deals with the form and structure of animals and plants. So, mathematical morphology is a tool for extracting image components that are useful in the representation and description of region shape, such as boundaries, skeletons and the convex hull. It is based upon set theory. It offers a unified and powerful approach to numerous image processing problems. Sets in mathematical morphology represent objects in an image. Set reflection and translation are employed extensively in morphology to formulate operations based on so called structuring elements (SEs) [1]. In computer vision, it is used as tool to extract image components that are useful in the representation and description of object shape. It is mathematical in the sense that the analysis is based on theory, topology, and lattice algebra, function and so on [2]. Another use of it is to filter image. It is a well known non-linear filter for image enhancement ([3], [4], [5]). . Morphological filtering simplified segmented images by smoothing out object outlines using filling small holes, eliminating small projections [3]. Morphological image processing pursues the goals of removing these imperfections by accounting for the form and structure of the image. These techniques can be extended to grayscale images. Mathematical morphology is a new mathematical theory which can be used to process and analyze the images. It is mathematical in the sense that the analysis is based on theory, topology, and lattice algebra, function and so on. Another use of it is to filter image. It is a well known non-linear filter for image enhancement. It analyzes the images using set theory instead of mathematical modeling and analysis. Morphological operations rely only on the relative ordering of pixel values, not on their numerical values, and therefore are especially suited to the processing of binary images. Morphological operations can also be applied to grayscale images such that their light transfer functions are unknown and therefore their absolute pixel values are of no or minor interest. Medical images edge detection is an important work for object recognition of the human organs, and it is an essential pre- processing step in medical image segmentation. The work of the edge detection decides the result of the final processed image.

II. TRADITIONAL OPERATORS

Some traditional operators are as below:

A. First order derivative / gradient methods are as follows:
1) Roberts operator
2) Sobel operator
3) Prewitt operator

B. Second order derivative:
1) Laplacian
2) Laplacian of Gaussian
3) Difference of Gaussian

C. Optimal edge detection:
1) Canny edge detection

Sobel operator is used in image processing techniques particularly in edge detection. The Sobel operator is based on convolving the image with a small, separable, and integer valued filter in horizontal and vertical and is therefore relatively

inexpensive in terms of computations. Mathematically, the operator uses two 3×3 kernels which are convolved with the original image to calculate approximations of the derivatives - one for horizontal changes, and one for vertical.
Prewitt operator edge detection masks are the one of the oldest and best understood methods of detecting edges in images. Basically, there are two masks, one for detecting image derivatives in X and one for detecting image derivative in Y. To find edges, a user convolves an image with both masks, producing two derivative images (dx and dy). The strength of the edge at given location is then the square root of the sum of the squares of these two derivatives. The Prewitt edge detector is an appropriate way to estimate the magnitude and orientation of an edge. Although differential gradient edge detection needs a rather time consuming calculation to estimate the orientation from the magnitudes in the x- and y-directions, the Prewitt edge detection obtains the orientation directly from the kernel with the maximum response. The set of kernels is limited to 8 possible orientations; however experience shows that most direct orientation estimates are not much more accurate. Roberts edge detection method is one of the oldest method and is used frequently in hardware implementations where simplicity and speed are dominant factors.

Canny edge detection operator was developed by John F. Canny in 1986 and uses a multistage algorithm to detect a wide range of edges in images. Stages of the Canny algorithm are noise reduction and non-maximum suppression.

III. MORPHOLOGICAL OPERATORS

Some mathematical morphological operators are as below ([6], [7]):

A. Erosion: Shrinking the foreground
B. Dilation: Expanding the foreground
C. Closing: Removing holes in the foreground
D. Opening: Removing stray foreground pixels in background

A. Dilation:

The dilation process is performed by laying the structuring element **B** on the image **A** and sliding it across the image in a manner similar to convolution. The difference is in the operation performed. The different steps of dilation are:
1. If the origin of the structuring element coincides with a 'white' pixel in the image, there is no change; move to the next pixel.
2. If the origin of the structuring element coincides with a 'black' in the image, make black all pixels from the image covered by the structuring element.
The Notation is as under:

$A \oplus B$
(1)

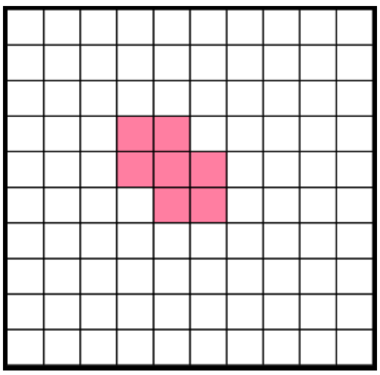


Fig. 1 Original [8]

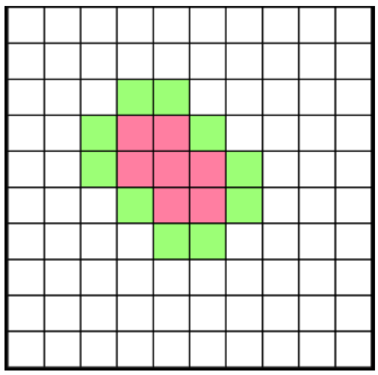


Fig. 2 Applied Mask [8]

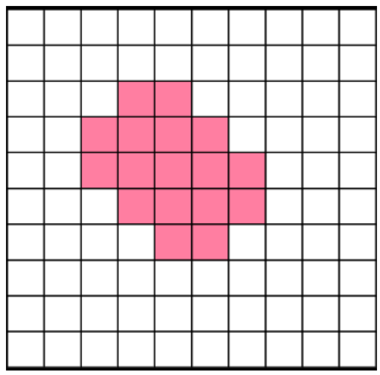


Fig. 3 Dilated image [8]

B. Erosion:

The erosion process is similar to dilation, but we turn pixels to 'white', not 'black'. As before, slide the structuring element across the image and then follow these steps:

1. If the origin of the structuring element coincides with a 'white' pixel in the image, there is no change; move to the next pixel.

2. If the origin of the structuring element coincides with a 'black' pixel in the image, and at least one of the 'black' pixels in the structuring element falls over a white pixel in the image, then change the 'black' pixel in the image (corresponding to the position on which the center of the structuring element falls) from ‘black’ to a 'white'.
The Notation is as under:

$A \Theta B$

(2)

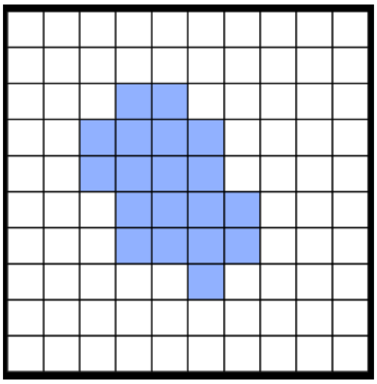


Fig. 4 Original [8]

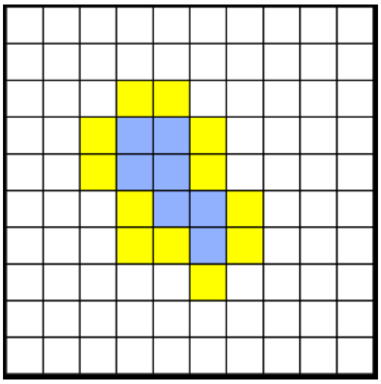


Fig. 5 Applied Mask [8]

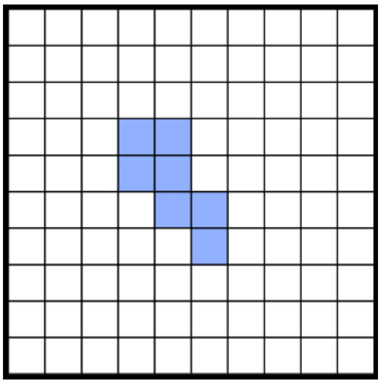


Fig. 6 Eroded image [8]

C. Opening and Closing:

These two basic operations, dilation and erosion, can be combined into more complex sequences. The most useful of these for morphological filtering are called opening and closing [3]. *Opening* consists of an erosion followed by a dilation and can be used to eliminate all pixels in regions that are too small to contain the structuring element. In this case the structuring element is often called a probe, because it is probing the image looking for small objects to filter out of the image.

The Opening process is as below:

$$A \circ B = (A \Theta B) \oplus B \qquad (3)$$

The Closing Process is as below:

$$A.B = (A \oplus B) \Theta B \qquad (4)$$

Erosion filters the inner image while dilation filters the outer image. Opening generally smoothes the contour of an image, breaks narrow gaps. As opposed to opening, closing tends to fuse narrow breaks, eliminates small holes, and fills gaps in the contours. Therefore, morphological operation is used to detect image edge, and at the same time, denoise the image.

IV. Structuring Element

Morphological techniques probe an image with a small shape or template called a structuring element. The structuring element is positioned at all possible locations in the image and it is compared with the corresponding neighborhood of pixels. Some operations test whether the element "fits" within the neighborhood, while others test whether it "hits" or intersects the neighborhood. A structuring element is simply a binary image that allows us to define arbitrary neighborhood structures. The structuring element is a small binary image, i.e. a small matrix of pixels, each with a value of zero or one. The matrix dimensions specify the *size* of the structuring element. The pattern of ones and zeros specifies the *shape* of the structuring element. An *origin* of the structuring element is usually one of its pixels, although generally the origin can be outside the structuring element [7].

Different structuring elements are as follows:

Structuring Element of 2X2 matrice is as follows:

SE1= 1 1	SE2= 1 0	SE3= 0 1
1 1	0 1	1 0
	(45 degree)	(135 degree)

Structuring Element of 3X3 matrice is as follows:

SE1= 1 1 1	SE2= 1 1 1	SE3= 1 0 1	SE4= 0 1 1	SE5=1 1 0
1 1 1	0 0 0	1 0 1	1 0 1	1 0 1
1 1 1	1 1 1	1 0 1	1 1 0	0 1 1
	(180 degree)	(90 degree)	(135 degree)	(45 degree)

Structuring Element of 5X5 matrice is as follows:

SE1= 1 1 1 1 1	SE2=1 1 1 1 1	SE3=1 1 0 1 1	SE4= 0 1 1 1 1	SE5= 1 1 1 1 0
1 1 1 1 1	1 1 1 1 1	1 1 0 1 1	1 0 1 1 1	1 1 1 0 1
1 1 1 1 1	0 0 0 0 0	1 1 0 1 1	1 1 0 1 1	1 1 0 1 1
1 1 1 1 1	1 1 1 1 1	1 1 0 1 1	1 1 1 0 1	1 0 1 1 1
1 1 1 1 1	1 1 1 1 1	1 1 0 1 1	1 1 1 1 0	0 1 1 1 1
	(180 degree)	(90 degree)	(135 degree)	(45 degree)

V. PROPOSED ALGORITHM

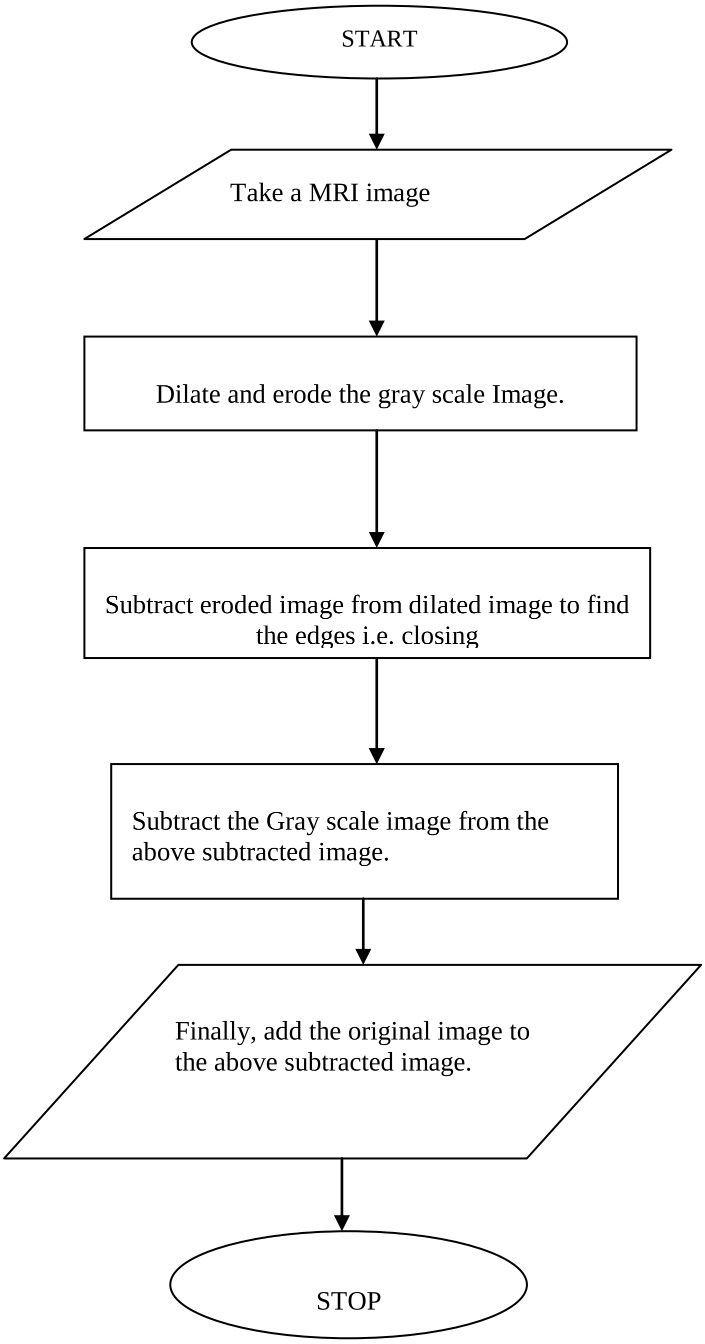
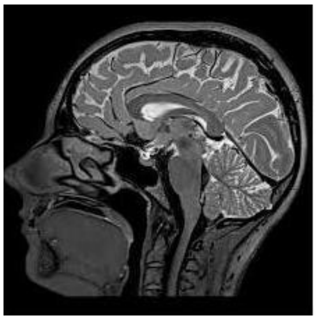


Fig. 7 Flow chart of Proposed Model

VI. RESULTS

The different results using proposed method are shown in figures 8 – 15 which are as follows:



3

Fig. 8 Original Image

Fig. 9 Gray Scale Image

The results of 2X2 SE are shown below:

Using SE1

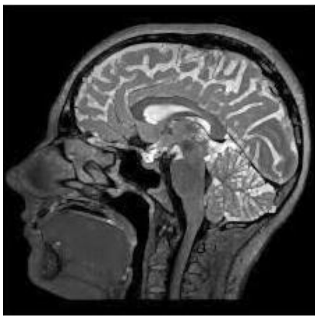


Fig. 10 Dilation

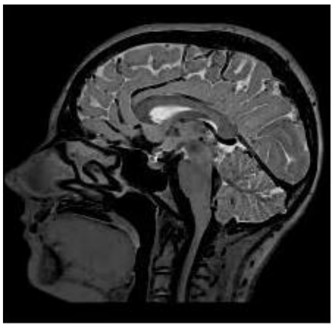


Fig. 11 Erosion

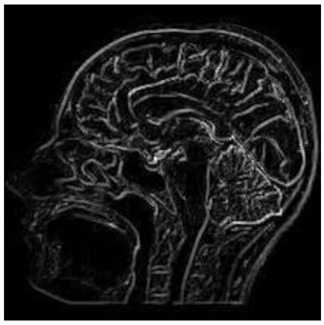


Fig. 12 Closing

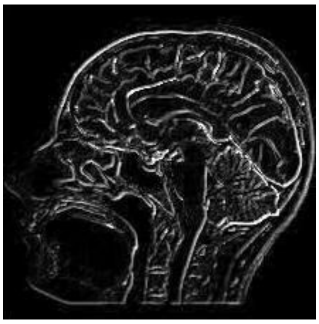


Fig. 13 Subtraction of original from closing

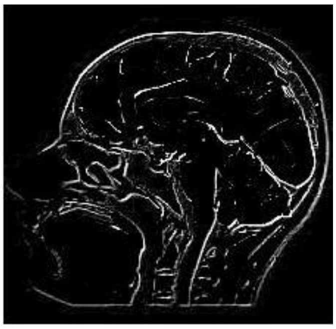


Fig. 14 Contrast adjusted for final image

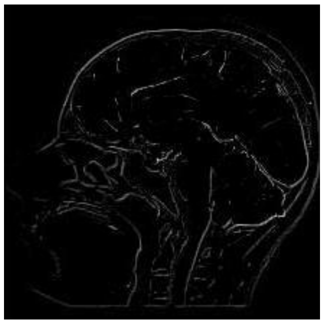


Fig. 15 Resultant image

VII. Conclusion:

The classical operator such as Sobel, and Prewitt which uses first derivative has very simple calculation to detect the edges and their orientations but has inaccurate detection sensitivity in case of noise. The disadvantages of LOG operator is that it cannot find the orientation of edge because of using the Laplacian filter. Hence, it is concluded that proposed method for detection of edges is simpler to use and after applying proposed algorithm, there is better result than the closing technique. Resultant image has more clear and continuous edges as compared to any other methods.

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