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Brain Tumor Edge Detection and Restoration Using Modified Morphology for MRI Images

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Abstract: *Medical image edge detection is an essential pre-processing step in image segmentation and restoration. The recognition of edges is useful for object identification of the human organs, to find the discontinuities in depth, changes in material properties, and variations in picture illumination. Proper classification plays a vital role in the analysis of medical images. In areas of feature extraction and detection the edge detection refers to algorithms aiming at identifying points where the image brightness changes sharply. In the proposed work a novel algorithm based on mathematical morphology is used to perform edge recognition on brain MRI images. The algorithm provides an efficient way for detecting the edges of brain tumour than the template based edge detection, gradient based algorithm. For images with noise the novel algorithm can filter out the noise effectively, and the edge is continuous, smooth and clear outline. The computational impediment of such a method is very less making it possible to have real time functioning of the proposed algorithm. The renovation of the original noise free image enhances the flexibility of the proposed algorithm. The proposed approach results show that the algorithm has a good effect in edge detection; restoration, antinoise ability, object assessment and visual effect are good, too.*

Keywords: *Medical Imaging, Tumor, Salt and pepper noise, Morphological Operators*

I. Introduction

Edge detection is commonly used in image processing applications to obtain the information from the images [11].The edge may be regarded as boundary between two dissimilar regions in an image. Edge detection of medical images is a critical concept in image processing used for object recognition of human organs such as lungs ribs etc., since edges contain a major part of image information. The function of edge detection is to identify the boundaries of homogeneous regions in an image based on properties such as intensity and texture. Edge detection is widely used in image segmentation, feature extraction and other fields. The traditional algorithms of edge detection are Laplace operator, Roberts Operator, Sobel operator, Canny operator and so on[4], each of them has different characteristics and pertinence. But these algorithms involve in orientation, so antinoise performance is generally poor and these become difficult to detect the edge of the complex image [5]. Image segmentation is an essential pre-processing step in medical image analysis and classification. Image segmentation approach subdivides the image in to its constituent parts or objects . The aim of segmentation is to simplify or change the representation of an image into something that is easier and meaningful during the analysis.. Canny [2] derived analytically optimal step edge operators and showed that the first derivative of Gaussian filter is a good approximation of such operators. Another alternative to gradient techniques is based on statistical approaches. The idea is to examine the distribution of intensity values in the neighborhood of a given pixel and determine if the pixel is to be classified as an edge [1]. Statistical methods are earlier approached by some authors [3] [5].Morphology became a tool in image processing which shows a great application prospect increasingly [8-9].The morphology can achieve the purpose of the image analysis and target recognition. It provides an alternative approach to image processing based on shape concept from set theory[10], not on traditional mathematical modeling and analysis. Due to performance of classic edge detectors degrades with noise, morphological edge detector has been studied [11]. In this paper a novel mathematical morphology edge detection algorithm is proposed to detect brain tumor. MRI medical image edge. It is better method for edge information detecting and noise filtering than differential operation, which is sensitive to noise. And it is a better compromise method between noise smoothing and edge orientation.

The acquired images are in the most cases corrupted with parasites or noises. The Processing to be applied to them depends on the information which one wants to extract. Indeed, the device and the conditions of acquisition are not always perfect; the image can present distortions or a blur. Thus, the restoration is necessary when the image is degraded. It consists in correcting the distortions introduced during the formation, the acquisition or the transmission of the image by a filtering operation. . Therefore, a frequent problem in low-level

vision arises from the wish to eliminate noise and uninteresting small scale details from the degraded image, without blurring semantically important structures in the image edges.

1.1. Review Of Current Methodologies

Edge detection is a primary problem of computer vision and is commonly investigated. For the past two decades several approaches were urbanized to extract the boundary or contour of homogeneous regions within digital image. Typically, the first stage of edge exposure (e.g. the gradient operator, Robert operator, the Sobel operator, the Prewitt operator) is the assessment of derivatives of the image intensity.

Canny [2] is a widely considered the standard method for edge detection uses a 3x3 smoothing window designed for arbitrary edges based on the specification of detection and localization criteria in mathematical form.. However, all the Gaussian and Gaussian-like smoothing filters, while smoothing out the noise, also remove genuine high frequency edge features, degrade localization and degrade the detection of low- contrast edges .Li Dong Zhang and Du Yan Bi [12] presented an improved morphological gradient edge detection algorithm which improves the edge resolution and insensitivity to noise. Deng Caixia,Chen Yu has proposed a improved algorithm of edge detection based on mathematical morphology where the algorithm can filter out the noise effectively and the edge is continuous , smooth and clear outline[]. Zhao Yu-qian et al. [14] proposed a novel mathematical morphological algorithm to detect lungs in CT medical image edge. They showed that this algorithm is more efficient for medical image denoising and edge detection than the usually used template-based edge detection algorithms such as LoG, Sobel edge detectors, and general morphological edge detection algorithms such as morphological gradient operation and dilation edge detector residue. Fesharaki, M.N.and Hellestrand, G.R [5] presented a new edge detection algorithm based on a statistical approach using the student t-test. They selected a 5x5 window and partitioned into eight different orientations in order to detect edges. One of the partitioning matched with the direction of the edge in the image shows the highest value for the defined statistic in that algorithm shows that this method suppresses noise significantly with preserving edges without a prior knowledge about the noise content in the image.J.Mehana [16] presented an algorithm for medical images edge detection based on mathematical morphology. The simulation result shows that the novel morphological edge detection is more efficient for edge detection and image denoising. Reecha Sharma and Beant Kaur[26] has proposed a algorithm for detection of edges using Mathematical morphology for X-Ray images. In this paper square type structuring element of different size is implemented on different image. Zhu.Y,Yan.H has proposed a new approach using a Hopfield neural network for detection of brain tumors. For real time processing the Hopfield neural network with its parallel processing potential the boundary detection can be implemented.[11]. Wiley wang has analyzed and compared various techniques for brain image segmentation. The paper proposed an automatic model technique for brain tumor segmentation by using SVM based classifier.[3]. Koschan.A. proposed a color image edge detection algorithm using pseudo complement and matrix rotation operations. Hence during the observation the dominant pixels are obtained by image differentiation between the complement image and matrix operated image.[18].

II. Frame Work Of Proposed Method

2.1. Morphology

Morphology is one of the most dynamic areas in the field of image processing [18].Mathematical morphology is used to carry out object removal, image filtering operations, such as removal of small objects or noise from an image segmentation operation. It is a new mathematical theory which can be used to process and analyze the images. The operations of morphology are defined by set theory. Based on set theory the operation transforms from one set to another. Nonlinear signal transformations are mathematical morphology that locally modify the geometrical features of image objects. Morphological filter provides a useful theoretical framework for an important class of shape based transformations. These filters simplify segmented images by smoothing out object outlines using filling small holes, eliminating small projections.

Basic primitive operations are dilation and erosion that use a structuring element to determine exactly how object will be dilated or eroded. Erosion is a transformation of shrinking, which decreases the grey scale value of the image. Erosion is defined as the minimum value in the window. The dilation increases the intensity and It shrinks or thins the image. Erosion process shrinks objects or images by changing the pixels with a value of '1' to '0'. Dilation is a transformation of expanding, which increases the grey scale value of the image. Dilation is defined as the maximum value in the window. Hence the image after dilation will be brighter or increased in intensity. It also expands the image and mainly used to fill the spaces. Dilation process expands the image objects by changing pixels with value of '0' to '1**'.B**oth of them are sensitive to the image edge which changes the grey scale value obviously. The inner image is filtered by erosion and outer image by dilation. Dilation process grows or thickens binary image objects by changing pixels with values. On the other hand the erosion process shrinks or thins the image objects. The behaviour of dilation and erosion are controlled by the shape of the structuring element. There is also a combination of dilation and erosion and combination called

opening and closing. erosion followed by dilation is opening operation. Closing is a dilation followed by erosion. Open operation generally smoothes the contour of objects, breaks narrow gaps, and eliminates thin potions. Close operation tends to smooth sections of contours fusing constricted breaks eliminate small holes and fills gaps in the shape. Therefore the morphological operation identifies image edge, and at the same time, denoises the image.

2.2 Selection of Structure element

Structure element is the fundamental feature of mathematical morphology. The structuring elements with its different sha pe and size play an important role. The shape and size of structural elements affect the edge detection results. The horizontal structure element is perceptive to the vertical edge; the vertical structure element is perceptive to the horizontal edge. The structure element smaller can detect the edge details but has facility to filter noise. The structure element larger has preferable ability to filter noise, but the edge detected is thicker than expected and small details of edges are not preserved. In medical images there are a number of fine details that need to be preserved; simultaneously we need to remove the noise effectively. For that reason in mathematical morphology the structure element is primary and crucial step edge detection based on mathematical morphology.

2.3 Proposed Method

Morphological edge detection algorithm selects an appropriate structuring element of the processed image and makes use of the fundamental theory of morphology including dilation, erosion and opening, closing operations, and the synthesization operations of them to get clear image edge. Information about the shape, connectivity, smoothness, and orientation can be obtained by means of a variety of structuring elements and morphological operators. The synthesized mode of the operations reflects the relation connecting the processed image and original image, and the choice of structuring element decides the accuracy and the result. Therefore, the keys of morphological operations can be generalized for the design of morphological filter structure and the selection of structuring element because the size of the structuring element control the sensitivity of edge detector.. In medical image edge detection, an suitable structuring element is selected to take out texture features, size, shape and direction of structuring element must been considered roundly. Usually, except for special demand, structuring element by 3×3 square is selected. By the operation features of morphology, erosion and dilation operations satisfy: [14]

$$F \Theta B \subseteq F \subseteq F \oplus B \quad \textbf{(1)}$$

Opening and closing operations satisfy:

$$F \circ B \subseteq F \subseteq F \bullet B \quad \textbf{(2)}$$

The description above shows that dilation and closing operations can enlarge the processed image while erosion and opening operations can reduce size of processed image. However the processed image is similar to the original image. Therefore, in morphological detection of edges, the mentioned algorithms are used for image edge detection. The edge of image F, which is represented by E_d (F), is stated as the distinction set of the dilation domain of F and the domain of F. This is also identified as dilation edge detector residue.

$$E_d(F) = (F \oplus B) - F \quad \textbf{(3)}$$

Accordingly, the edge of image F, denoted by E_e (F), can be defined as distinction set of the domain of F and the erosion domain of F. This is also known as erosion edge detector residue:

$$E_e(F) = F - (F \Theta B) \quad \textbf{(4)}$$

The dilation and erosion used often to analyse the morphological gradient of image F, denoted by $G(F)$:

$$G(F) = (F \oplus B) - (F \Theta B) \quad \textbf{(5)}$$

The opening top-hat transformation of image F, which is denoted by TH_0 (F) , is defined as the difference set of the domain of F and the opening domain of F . It is defined as

$$TH_o(F) = F - (F \circ B) \quad \textbf{(6)}$$

Similarly, the closing top-hat transformation of image F, which is denoted byTH_c (F), can be stated as the distinction set of the closing domain of F and the domain of F. It is defined as

$$TH_c(F) = (F \bullet B) - F \quad \textbf{(7)}$$

The top-hat transformation which owes its original name to the use of a cylindrical or parallelepiped structure element function with a flat top is useful for enhancing detail in the presence of shading. In this paper, a modified mathematical morphology edge detection algorithm is proposed. Opening and closing are used as pre-processing to filter noise. The next step is smooth the image by first closing and then dilation. The perfect image edge will be obtained performing the distinction between the processed image by above process and the image before dilation. The above operation is followed by open and closing operation to further smoothen the image. The proposed algorithm is given below:

$[(((M \bullet B) \oplus B) - (M \bullet B) \circ B) \bullet B]$ **(8)**

$M = (F \bullet B) \circ B$ **(9)**

The original image is reconstructed by creating a mask using image erosion operation of the noisy image. This process is followed by formation of mask from the noisy image. By means of the mask and the marker, the original image is reconstructed.

2.4 Proposed algorithm

Step1.Load the MRI image
Step2.Noise added to the original image
Step3. Morphology based edge detection operator is used to detect the edge on the noise added images
Step4. Dilation followed by erosion operation on the noisy image is performed to obtain the Mask.
Step5. Reconstruction is performed so as to reconstruct the original image Using the mask and the marker,
Step6. The correlation coefficient, PSNR, MAE are evaluated between the original image and reconstructed image for the proposed Modified morphological method.

III. Results

A Brain Tumor MRI image impregnated with salt and pepper noise is taken for analysis Fig.2. The results of edge detection are shown in Fig.3 with the existing morphological algorithm [14] and the proposed algorithm Fig.4. Comparing the two results, it is clear that the edges are smooth and continuity in edges is significant than the existing algorithm. The experimental results show that the algorithm is more efficient for medical image denoising and edge detecting than the usually used edge detection algorithms such as Sobel, canny and other operators. The proposed algorithm is further enhanced by reconstructing the original image from the noisy image Fig.5, and this feature makes the proposed algorithm more reasonable than existing algorithm.

From the Results it can be observed that edges and reconstructed image is clear in details and free of noise.

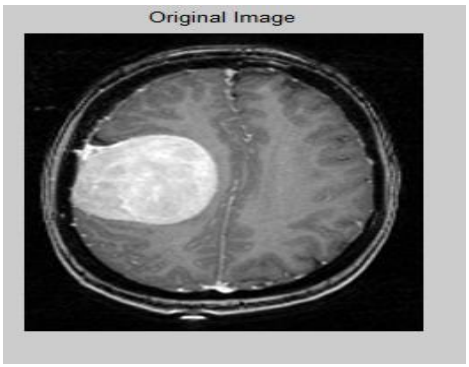

Fig 1: Input medical image

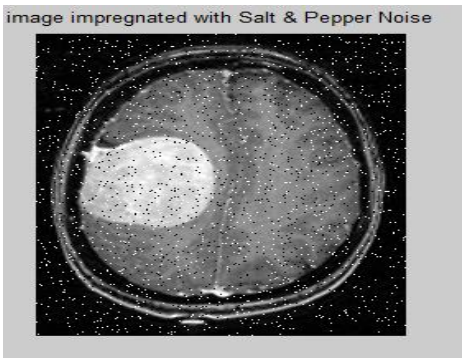

Fig 2: medical image with salt and pepper noise

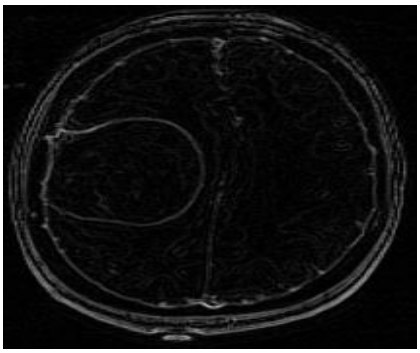

Fig 3.Edge as identified by basic morphological algorithm

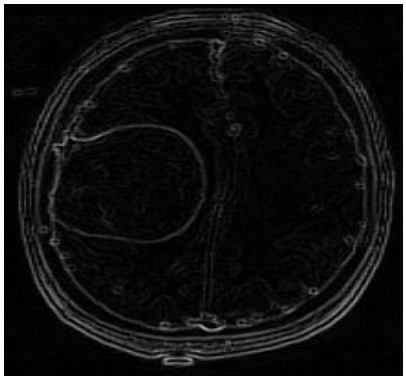

Fig 4: Edge as Identified by proposed Morphological Algorithm

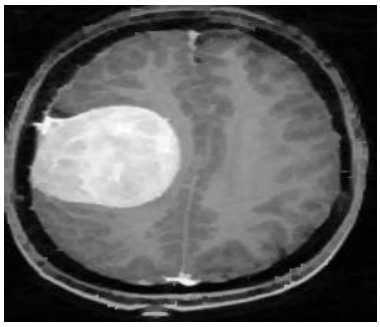

Fig 5: Reconstructed Image from the Noisy Image

Table 1. Statistical comparison

Method	PSNR	CC
Morphological operations	65.15	0.8346
Proposed Modified morphological operations	86.78	0.8813

The statistical results in the above table 1. Shows that the proposed method shows a better results than the existing morphological method and is even better for the given parameters. We can visually see that the proposed method gives much better results in all aspects. The detection results visual analysis show that the proposed method suppress the noise completely and may detect the edge. The previously used morphological edge detectors suppress the noise but gives poor edge detection. Where the fine edge details are not detected effectively. The proposed modified methods not only suppress noise but also detect the edge and meet the requirement of the real time.

IV. Conclusion

In this paper a novel mathematical algorithm is proposed to detect tumor edge from MRI image. The experimental results show that the algorithm is more efficient for medical image denoising and edge detecting than the usually template based edge detection and general morphological edge detection algorithm**.** The evaluation is made using correlation coefficient, peak signal to noise ratio(PSNR) and mean absolute error(MAE).The result obtained was the proposed mathematical morphology approach suits better for salt and pepper noise with high correlation coefficient, high PSNR**.**

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