Segmentation of Medical Images Using Morphological Approach

Pinaki Pratim Acharjya, Dibyendu Ghoshal

Abstract— The goal of image segmentation is to simplify and change the representation of an image into something that is more meaningful and easier to analyze. In recent days digital image segmentation plays a very important role in medical image analysis. In this paper a very effective image segmentation process for medical image segmentation has been presented. Objective of this paper is to segmenting the medical images using Laplacian of Gaussian (Log) operator with combination of watershed algorithm using distance transform for edge detecting human bones from X-Ray images.

Index Terms— image segmentation, medical image analysis, Laplacian of Gaussian, watershed algorithm.

1 INTRODUCTION

THE most important role of the segmentation [1], [2], [3], [4] process is to segregate an image into regions with one or more characteristics like color and object and the segmentation results are mainly for better analyzing and meaningful understanding images. In recent days image segmentation is a vital method for most medical image analysis tasks [6], [7], [8]. In image segmentation, edge detection is an important work for object recognition of the human organs such as brain, heart, kidney, tumor, bones etc. and it is an essential pre-processing step in medical image segmentation [5], [6], [7], [8], [9], [10]. Having good segmentations will help clinicians and patients as they provide vital information for 3-D visualization, surgical planning and early disease recognition.

Medical images, such as CT, MRI or X-Ray visualizes the various information's of internal organs which is very important for medical diagnoses as well as medical teaching, learning and research [5], [6], [7], [8], [9]. It is a tough job to locate the internal organs as these pictures contains noise or rough structure of human body organs. In this paper an effective segmentation and edge detection technique is proposed with the help of mathematical morphology. Mathematical morphology [1], [2], [11], [14], this term commonly denotes a branch of biology that deals with the form and structure of animals and plants. The same word have been used here in the context of mathematical morphology as 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. In morphological image processing watershed algorithm is a powerful tool for image segmentation. Several methods and approaches with watershed algorithm are found in published or online literature [11], [12], [13], [14], [15], [16], [17], [18], [19], [20]. This algorithm is applied in this paper using distance transform and Laplacian and Gaussian operator for achieving the image segmentation process.

This paper is divided into various sections. Section 2 introduces a brief description Laplacian of Gaussian (Log) operator. Section 3 introduces the Watershed with Distance Transform. Section 4 presents the proposed scheme. The experimental results are discussed in section 5 and we finish this paper with some concluding remarks with section 6.

2 LAPLACIAN OF GAUSSIAN

The Laplacian of Gaussian operator (LOG) plays a very important role in image segmentation. It is a convolution filter that is used for edge linking and edge maping of different objects. This filter first applies a Gaussian blur, then applies the Laplacian filter and finally checks for zero crossings, i.e. when the resulting value goes from negative to positive or from negative to positive. The main objective of this filter is to

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highlight edges different objects. As a input the LOG operator takes a single gray level image and produces another binary image as output. A 5x5 mask LOG filter has been shown below.

0	0	-1	0	0
0	-1	-2	-1	0
-1	-2	16	-2	-1
0	-1	-2	-1	0
0	0	-1	0	0

Fig 1. A conventional 5x5 LOG surround filter.

3 WATERSHED ALGORITHM USING DISTANCE TRANSFORM

Watershed transform is the technique which is commonly used in image segmentation in mathematical morphology. It is now being recognized as a powerful method used in image segmentation due to its many advantages such as simplicity, speed and complete division of the image. Watershed transform or Watershed Algorithm is based on grey-scale morphology. It is classified as a region-based segmentation approach. Even when the target regions having low contrast and week boundaries, watershed transformation can provide closed contours. When a landscape or topographic relief is flooded with water, the divide lines of the domains of rain falling over the regions forms the watersheds. Intuitively, a drop of water falling on a topographic relief flows towards the "nearest" minimum. The "nearest" minimum is that minimum which lies at the end of the path of steepest descent. In terms of topography, this occurs if the point lies in the catchment basin of that minimum. An alternative approach is to imagine the landscape being immersed in a lake in which holes are pierced in the local minima is called the catchment basin. Water will be filled up at these starting local minima and at points where water coming from different basins would meet and dams will be built. When the water level reaches the highest peak in the landscape the process is stopped. As a result, the landscape is partitioned into regions or basins separated by dams, called watershed lines or simply watersheds.

Distance transform is a common tool used in watershed transform for image segmentation. The concept is, the distance from every pixel to its nearest non zero valued pixel. Every single valued pixel has a distance transform value of 0, as it is the closest non zero valued pixel of itself. An example is given below, of a binary matrix and its distance transform value.

1	1	0	0	0
1	1	0	0	0
0	0	0	0	0
0	1	1	1	0

(a)

0.00	0.00	1.00	2.00	3.00
0.00	0.00	1.00	2.00	3.00
1.00	1.00	1.41	2.00	2.24
1.41	1.00	1.00	1.00	1.41
1.00	0.00	0.00	0.00	1.00

(b)

Fig 2. (a) shows a binary image matrix, and (b) shows the corresponding distance transform.

4 METHODOLOGY

A new methodology have been tried for obtaining better result in image segmentation and human bone edge detection on watershed algorithm using distance transform with the combination of Laplacian of Gaussian operator. The proposed methodology is a two stage process. The first process uses Laplacian of Gaussian operator to produce an edge map of primary segmentation of the input image, while the second process applies the watershed algorithm using distance transform to the primary segmentation to obtain the final segmentation map. The flowchart shown in figure 3 describes the proposed method. In the proposed methodology, firstly a color image is chosen, and converted to grayscale image. Secondly, 'log' operator is used for edge map detection. Thirdly image complement is obtained from the previous resulted image. The distance transform is estimated in the next step. And finally watershed algorithm has been applied to the image to get the final segmented image or the desired result.

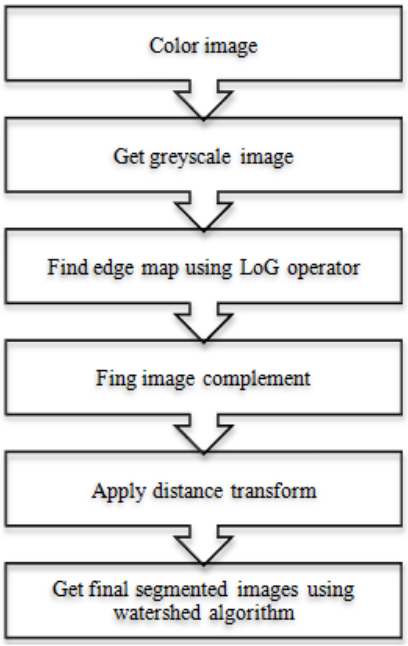


Fig 3. Flowchart of the proposed methodology.

5 EXPERIMENTAL RESULTS

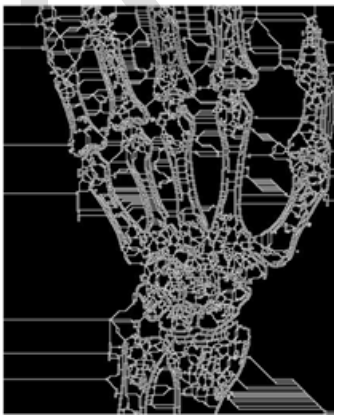
The proposed methodology has been applied on three X-Ray images of hand, finger and knee of dimensions of 586 x 607, 456 x 341 and 481 x 486 accordingly. The original images are shown in figure 4(a), 4(b) and 4(c) respectively. In final segmented images which are shown in figure 5 (a), 5(b) and 5(c) respectively, segmentation maps are obtained which are more diplomats of the several anatomies in the medical images with lesser over segmentation. Mathematical measurements are also shown in table 1.

(a)

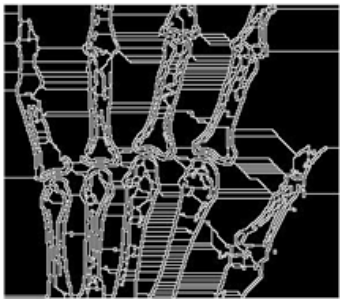
(b)

(c)

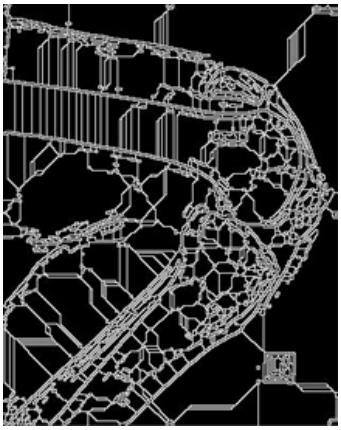
Fig 4. Original X-Ray images. (a) Hand, (b) Fingers, (c) knee.



(a)



(b)



(c)

Fig 5. Final segmented images. (a) Hand, (b) Fingers, (c) knee.

TABLE 1
Statistical measurement

IMAGE	ENTROPY	PSNR	MSE
Segmented image of Hand	5.4270	10.6270	5.6283e+003
Segmented image of Fingers	4.7350	10.9968	5.1690e+003
Segmented image of Knee	4.5978	8.3898	9.4211e+003

6. CONCLUSION

An effective method which integrated Laplacian of Gaussian operator for generating edge map with the watershed algorithm using distance transform for final segmentation process has been proposed. The main goal or objective of this method is to segmentation of biomedical images and edge detection of human bones edges from X-Ray images. The experimental results had shown that the proposed method is very effective for detection of bones irrespective of clarity and sharpness with lesser over segmentation.

DEDICATION

One of the others (Dibyendu Ghoshal) dedicates the entire study to the loveliest and loving memory of his only one and younger sister Kumari Sumita Ghoshal who herself was a gem of the scholars, a symbol of wisdom and art, peerless beauty and simplicity, unfathomable knowledge and generosity.

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