Watershed Segmentation based on Distance Transform and Edge Detection Techniques

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ABSTRACT
An edge detection algorithm for digital images is proposed in this paper. Edge detection is one of the important and most difficult tasks in image processing and analysis. In images edges can create major variation in the picture quality where edges are areas with strong intensity contrasts. Edges in digital images are areas with strong intensity contrasts and a jump in intensity from one pixel to the next can create major variation in the picture quality. This paper proposed an effective edge detection algorithm based morphological edge detectors and watershed segmentation algorithm using distance transform. The result confirms that the proposed algorithm is found to yield satisfactory and efficient segmentation of the digital images for edge detection. Experimental result presented in this paper is obtained by using MATLAB.

Keywords
Edge detection, Segmentation, Distance Transform, Watersheds.

1. INTRODUCTION
Image segmentation has been an essential step in digital image processed for most subsequent image analysis and image understanding activities. In specific, many of the prevailing method for image description and recognition [1-2], image visualization [3-4], and object based image compression [5-7], highly depend on the segmentation result obtained from previous stage. The segmentation problem [10], [12] involves separating or partitioning of an image into a number of homogenous and spatially connected group of pixels called super pixels, so it has addition of two neighborhood segments produces a heterogeneous segment. As an alternative approach, segmentation can be thought of as a pixel labeling cum mathematical morphological process in the same that all the pixels belonging to the same homogeneous region are assigned the same label and theme and several techniques to define homogeneity of a region based on a particular objective of image segmentation process.

Stellar images of various planets, stars, galaxies, comets, nebula and other various extra terrestrial moving objects have occupied a significant place in radio astronomy, space research and preparation of distance space vehicle movements (manual or robotized) [8]. The images of stellar objects have been acquired either through satellite imagery or Hubble space telescope. These images are very much prone to be affected by a verity of noise like Gaussian noise, Rayleigh noise, Impulse noise and Speckle noise. At the same time, the contrast of these images have been generally found to be low to very long distance and atmosphere turbulence and disturbance and variation of temperature during the transmission of them through space media. The segmentation of low contrast images have always posed problem due to processing problem arising from inability to directly apply the watershed algorithm on the image. Rather it has been found to be more suitable to apply watershed to the gradient of the image instead of the original image [20]. In this approach, the original minima of catchment basins correlate with the small values of the image gradient value. Thus the study of the effect of application of varies modified version or combination of morphological based watershed algorithm [9], [14-19]on low contrast images of stellar objects have become worthwhile and interesting.

A good number of methods have been proposed and applied to solve the problem related to digital image segmentation [11], [13]. These techniques can be broadly classified into the following categories as histogram based techniques, edge based techniques, region based techniques, markov random field based techniques and hybrid techniques. All the above techniques have got certain advantages as well as some complexity compared to the others, the present technique would fall within the group of processing having adaptive histogram equalization as a preprocessing step for low contrast stellar images.

2. THE WATERSHED SEGMENTATION
Watershed algorithm is based on morphological process although it can be mixed up with edge based segmentation to yield a hybrid technique. In geography, watersheds are the ridge line that divides different areas called catchment basins drained by different river systems. In mathematical morphology, a gradient image may be considered as a topological surface where the numerical value of each pixel indicates the evaluation of their points. The set of pixels along which the gray levels changes sharply gives rise to an edge. The watershed algorithm applies these ideas to solve a variety of image segmentation problems.

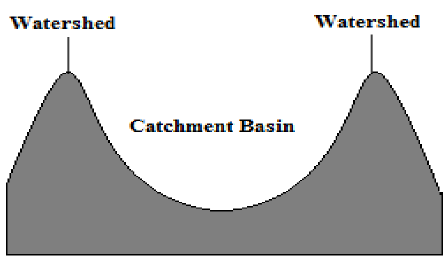

Fig 1: Watershed segmentation-local minima of gray level yield catchment basins, local maxima define the watershed lines.

Assume, M_i where $i= 1$ to n be the set of coordinates points in the regional minima (catchment basins), of the image *P(x,y)* and $C(M_i)$ be the coordinates points of catchment basins associated with the regional minima M_i

$$Tn = \{(s,t) \mid P(s,t) < n\} \tag{1}$$

Where,

T[n] = set of points in *P(x,y)* which are lying below the plane *p(x,y) = n*

min, max = minimum or maximum gray level value.

n = stage of flooding varies from min + 1 to max + 1

Let $C_n(M_1)$ be the set of points in the catchment basin associated with M_1 that are flooded at stage n.

$$Cn(M1) = \cap \{C(M1), T[n]\} \tag{2}$$

Where,

$$Cn(M_i) = \begin{cases} 1, & if\ (x,y) \in C(M_i) and (x,y) \in T[n] \\ 0, & otherwise \end{cases} \tag{3}$$

C[n] is the union of flooded catchment basin portions at the stage *n*.

Where,

$$C[n] = Cn(m1) \cup Cn(m2) \ldots\ldots Cn(mR) \tag{4}$$

$$C[max + 1] = C(m1) \cup C(m2) \ldots\ldots C(mR) \tag{5}$$

If the algorithm keeps on increasing flooding level then $C_n(M_i)$ and *T[n]* will either remain constant or increase. Algorithm initializes$C[min + 1] = T[min + 1]$, and then precedes recursively by assuming that at step n *C [n - 1]* has been constructed.

Let, *G* is a set of connected components in *T[n]* and for each connected component $g \in G[n]$, there possibilities will arise.

1. $g \cap C[n - 1]$ is empty.

2. $g \cap C[n - 1]$ contains one connected component of *C[n - 1]*.

3. $g \cap C[n - 1]$ contains more than one connected component of *C[n - 1]*.

3. WATERSHED SEGMENTATION USING THE DISTANCE TRANSFORM

The distance transforms of a binary image is the distance from every pixel of the object component which is black pixels to the nearest white pixel. In binary images there are only two gray levels 0 and 1 where 0 stand for black and 1 stands for. Only one catchment basin will appear in the topographic of a binary image surface only when two black blobs are connected together. In this article,, the distance transforms along with canny edge detector have been used to preprocess the image to make it suitable for watershed segmentation. In below, figure 2(a) shows a binary image matrix, and in figure 2(b) shows the corresponding distance transform.

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. PROPOSED ALGORITHM

The image (Fig 3), being a distance object has low contrast. These may be various interferential factors in such type of images such as non uniform illumination, variation in temperature of the ambience, atmospheric disturbance and turbulence, variation in the intensity and contrast etc. All these factors would enhance the difficulty of segmentation of galactic images. Thus a meaningful and effective measure is warranted to alleviate the adverse influence. So some image processing method would have to be applied and the image preprocessing stage comprises a number of methods such as gray level transformation, contrast enhancement, image de noising, image smoothing, sharpening and so on.

This approach deals with catchment basins and watershed ridge lines in an image by assuming it as a surface where light pixels are low. But most important contrast of an image is very important for image segmentation. It is the difference in visual properties that makes difference between one object of an image from the background or we can say it is the difference in the color and brightness of the object. So for satisfactory image segmentation image with satisfactory resolution is essential. In this approach, for low contrast stellar images we have used watershed with markers. In the initial step shown in figure 4, one stellar image is chosen, where contrast of that image is low and appropriate area is cropped which is shown in figure 5. We need to adjust the contrast. Contrast adjustment is necessary for good image understanding and analyzing. In figure 6, the image contrast is adjusted with adaptive histogram equalization method. In figure 7 we have applied threshold. In figure 8, we have clean up and overlay the perimeter on the original image by using imoverlay function, This function takes input image and a binary mask and generates an output image, where masked pixels have been replaced by a specified color. In figure 9, we apply markers for object and background. The extended maxima operator is used to identify groups of pixels that are significantly higher than their immediate surroundings. Again cleaning up and overlying is there in figure 10 and compute the complement of the image so that the peaks become valleys and modifies the image using imimposemin function. Finally we will sum up the watershed transform in figure 11 along with consequence examination. In this paper we study this approach with a low contrast image of a galaxy and detecting it. The flowchart of the proposed method is given below in figure 4.

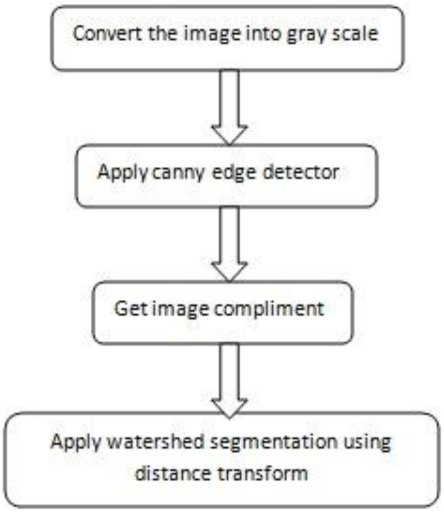

Fig 3: Flowchart of the proposed method.

5. RESULTS AND DISCUSSION

The experiments are carried out to evaluate the performance of proposed method with existing watershed segmentation using distance transform method and with the usually used differential edge detection operators such as Sobel edge detector or LoG edge detector with the combination of morphological watershed segmentation using distance transform.

The proposed method has been tested on the image of Lena with the size of {512 x 512} and with 256 gray levels (Figure 4). The final segmentation results are shown in figures (5, 6, 7, and 8). It can be observed from the final segmented images that the final resultant image with proposed approach (Figure 8) produced better results compared to to traditional watershed segmentation using distance transform method (Figure 5) and the usually used differential edge detection operators such as Sobel edge detector (Figure 6) or LoG edge detector (Figure 7) with the combination of morphological watershed segmentation using distance transform.

According to results canny edge operator is more efficient for edge detection with watershed segmentation using distance transform method where the other methods produced week edges for Lena image. The histograms of the final resultant images have been shown in figure (9, 10, 11, and 12). The performance of Segmentation algorithm is measured with the help of Entropy and (Table 1) as in term of visual quality of the original image and the resulted image.

Fig 4: Original image of Lena.

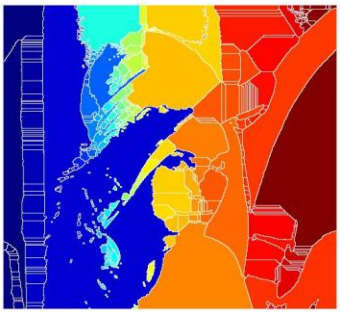

Fig 5: Traditional watershed segmented image using distance transform.

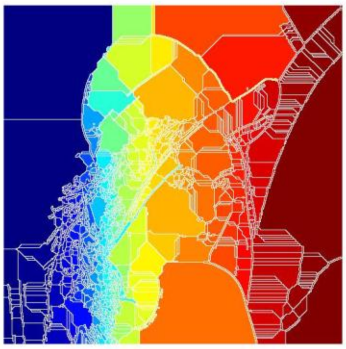

Fig 6: Watershed segmented image using distance transform with sobel edge detector.

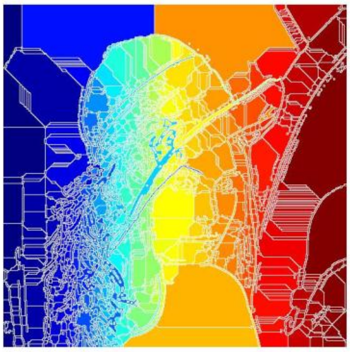

Fig 7: Watershed segmented image using distance transform with LoG edge detector.

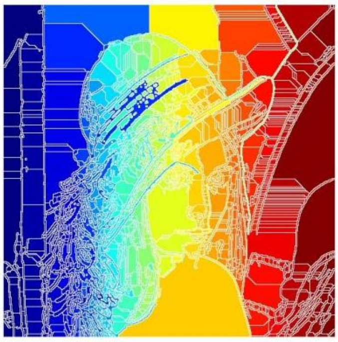

Fig 8: Watershed segmented image using distance transform with canny edge detector.

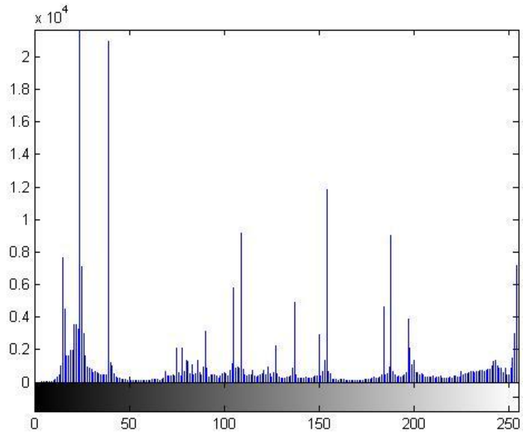

Fig 9: Histogram of watershed segmented image using distance transform.

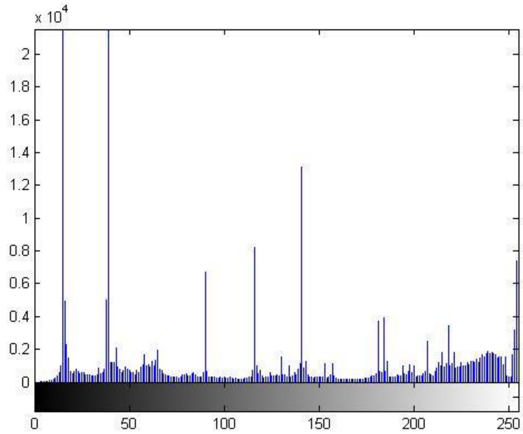

Fig 10: Histogram of watershed segmented image using distance transform with LoG edge detector.

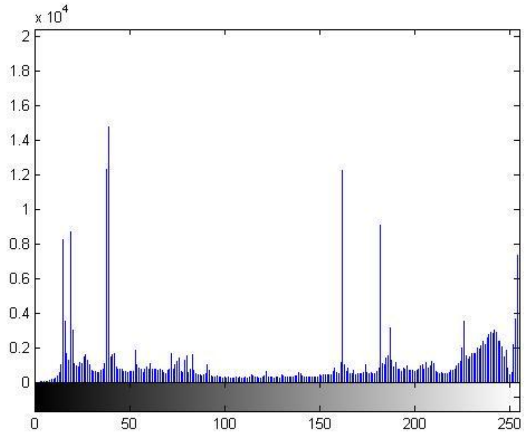

Fig 11: Histogram of watershed segmented image using distance transform with LoG edge detector.

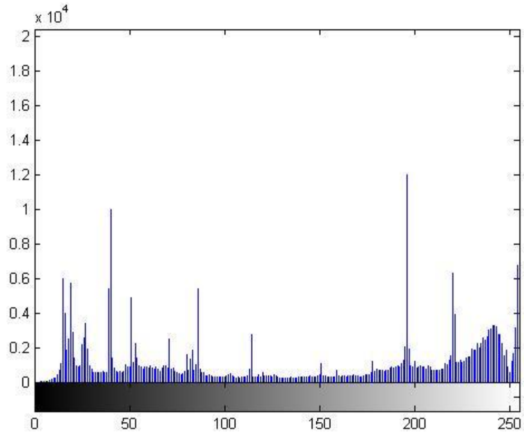

Fig 12: Histogram of watershed segmented image using distance transform with canny edge detector.

Table I- statistical measurement

IMAGE	ENTROPY	ELAPSED TIME
Watershed segmentation using distance transform.	4.3318	1.523536 seconds.
Watershed segmentation using distance transform with sobel edge detector.	4.6451	1.887422 seconds.
Watershed segmentation using distance transform with LoG edge detector.	4.8717	1.776297 seconds.
Watershed segmentation using distance transform with cannyl edge detector.	4.9610	2.002153 seconds.

6. CONCLUTSONS

In this paper, an effective morphological edge detection algorithm is proposed to detect image edge. The technique is very useful for Image segmentation and classification. The given experimental result shows that the algorithm produces more efficient results compared to traditional watershed segmentation using distance transform algorithm and the usually used differential edge detection operators such as Sobel edge detector or LoG edge detector with the combination of morphological watershed segmentation using distance transform. The detected edges are more sharp, pinpointed and clear with abundant edge information. Moreover, the proposed algorithm can filer the noise more effectively than traditional watershed segmentation using distance transform algorithm.

7. ACKNOWLEDGEMENT

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8. DEDICATION

One of the others (Dibeyendu 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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