

Mathematical Morphology based gray scale Image Segmentation using improved watershed transform

Manisha Gupta¹, Abdul Wahid Ansari², Mannika Garg³

(Asst. Professor¹, Graduate Student², Graduate Student³)

(University of Petroleum and Energy Studies, India)

(gmanisha03@yahoo.com¹, awahidansari.re@gmail.com², mannika91.garg@gmail.com³)

Abstract:-Mathematical Morphology provides systematic approach to analyze geometric Characteristic of signal or images, has been applied to many application such as Edge Detection, Object segmentation, noise suppression. Image segmentation is one of the most important categories of image processing. The watershed transformation for image segmentation using mathematical morphology is widely used. When we use watershed transform is image, there is a serious cause of over segmentation. In this paper the proposed system has been applied to overcome the over segmentation problem by using improved segmentation and efficient technique for image segmentation using mathematical morphology.

Keywords: Mathematical Morphology, Segmentation, Morphology gradient, watershed transform, marker controller, over segmentation.

Introduction: - Mathematical Morphology [18] is an nonlinear branch of the signal processing field and concern the application of set theory concept to image analysis. Morphology refers to the study of shapes and structures from a general scientific perspective, filters or operators are nonlinear transformation [17, 18], which modify geometric feature of images. An image by reconstruction [21, 22] has become a powerful tool that enables us to eliminate undesirable features without necessarily affecting desirable one. The morphological image reconstruction – based algorithm used in this paper to obtain the result better than general opening reconstruction and avoid some of inconveniences.

1. Mathematical Morphology:-

The morphology refers to the study of shapes and structure from a general scientific perspective, it can be interpreted as shapes study using mathematical set theory[11, 12].

Some of the silent points regarding the morphological approach are follows [10]:

- Morphology operations provides for systematic alteration of the geometric

content of an image while maintaining the stability of the important geometric characteristics.

- There exists a well-developed morphological algebra that can be employed for representation and optimization.
- It is possible to express digital algorithms in terms of a very small class of primitive morphology operations.

Morphology algorithms developed till dates are basically categorized as follows:

- **Binary Morphology:** - The theoretical fundamentals of binary mathematical morphology is set theory, those points in the sets are called the ‘foreground’ and those in the complement sets are called ‘background’.
- **Gray-scale Morphology:-** Binary morphology is extended to the gray – scale and maximum and minimum function is defined for operations.

2. Image Segmentation and Watershed Transform:-

Segmentation is the process of partitioning a digital into multiple segments of pixels , also known as super pixels. The result of image segmentation is a set of segments that collectively cover the entire image, or a set of contours extracted from the image (edge detection). Each of the pixels in a region are similar with respect to some characteristic or computed property, such as color, intensity, or texture. Adjacent regions are significantly different with respect to the same characteristic. applications of image Segmentation: Medical Imaging ,Locate tumors and other pathologies ,Measure tissue volumes ,Computer-guided surgery ,Locate objects in satellite images (roads, forests, etc.).

2.1.Watershed transformation:-

The Watershed Transformation considers the gradient magnitude of an image as a topographic surface. Pixels having the highest gradient magnitude intensities (GMIs) correspond to watershed lines, which represent the region boundaries. Water placed on any pixel enclosed by a common watershed line flows downhill to a common local intensity minimum (LIM). Pixels draining to a common minimum form a catch basin, which represents a segment. The initial concept of the watersheds transformation as a morphological tool was introduced by H. Digabel and C. Lantuéjoul in [7]. Later, a joint work of C. Lantuéjoul and S. Beucher led to the ‘inversion’ of this original algorithm in order to extend it to the more general framework of grayscale images.

2.2.Over segmentation:-

The watersheds transformation makes a number of regions as an output. For example, a human can clearly see a woman with background in Figure 3.4. This is because humans are capable of understanding the ‘semantics’ of a given scene; however, this image has 2976 different regions after the watersheds transformation. This over segmentation problem comes mostly from the noise and quantization error.

2.3.Marker-Controlled Watershed Segmentation:-

Separating touching objects in an image is one of the more difficult image processing operations. The watershed transform is often applied to this problem. The watershed transform finds catchment basins" and "watershed ridge lines" in an image by treating it as a surface where light pixels are high and dark pixels are low.

Segmentation using the watershed transform works better if you can identify, or "mark," foreground objects and background locations.

2.4.Creating Markers:-

The marker-controlled watershed segmentation has been shown to be a robust and flexible method for segmentation of objects with closed contours, where the boundaries are expressed as ridges. The marker image used for watershed segmentation is a binary image consisting of either single marker points or larger marker regions, where each connected marker is placed inside an object of interest.

Each initial marker has a one-to-one relationship to a specific watershed region, thus the number of markers will be equal to the final number of watershed regions. After segmentation, the boundaries of the watershed regions are arranged on the desired ridges, thus separating each object from its neighbors. The markers can be manually or automatically selected, but high throughput experiments often employ automatically generated markers to save human time and resources.

2.5.Morphological Image Reconstruction:-

Dilation-Based Gray-Scale Image Reconstruction

Let I, J be the two images defined on the same domain and $J \leq I$. The reconstruction of I from J , denoted as $Y_I^{(rec)}(J)$, is obtained by iterating elementary geodesic dilations of J under I until stability is reached,

$$y_I^{(rec)}(j) = \bigcup_{n \geq 1} \delta^{(n)}(j), \quad (2.1)$$

where $\delta^{(I)}(J)$ can be obtained by iterating an elementary geodesic dilation and the geodesic dilation is defined as

$$\delta^{(I)}(J) = (J \oplus b) \cap I \quad (2.2)$$

(b is the flat structuring element of size I and \cap stands for point wise minimum).

Erosion-Based Gray-Scale Reconstruction

Let I, J be two gray-scale images defined on the same domain and $J \leq I$. The reconstruction of I from J , denoted as $\phi_I^{(rec)}(J)$, is obtained by iterating elementary geodesic erosions of J above I until stability is reached,

$$\phi_I^{(rec)}(J) = \bigcap_{n \geq 1} \epsilon^{(n)}(J), \quad (2.3)$$

where $\epsilon^{(n)}(J)$ can be obtained by iterating n elementary geodesic dilation and the geodesic dilation is defined as

$$\epsilon^{(I)}(J) = (J \ominus b) \cup I, \quad (2.4)$$

(b is flat structuring element of size I and \cup stands for point wise maximum).

Local minima consist of a small number of pixels or have a low contrast with respect to their neighbors. The procedure to eliminate local minima adopted is in [10], [11]. The morphological reconstruction transformation is well known in the binary case, where it simply extracts the connected components of an image, which are “marked” by another image. Extending it to gray-scale reconstruction, it can accomplish several tasks such as image filtering, domes, and basin extraction. In this paper, we used improvised image reconstruction algorithm

3. Algorithm Proposed:-

- (i) Read the color image and convert it to gray-scale.
- (ii) Develop gradient images using appropriate edge detection function.

(iii) Mark the foreground objects using morphological reconstruction (better than the opening image with a closing).

(iv) Calculating the regional maxima and minima to obtain the good forward markers.

(v) Superimpose the foreground marker image on the original image.

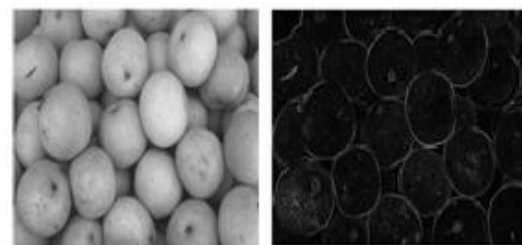
(vi) Clean the edges of the markers using edge reconstruction.

(vii) Compute the background markers.

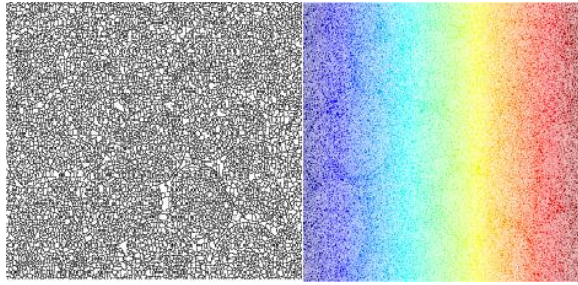
(viii) Compute the watershed transform of the function.

3.1. Implementation of watershed transform:-

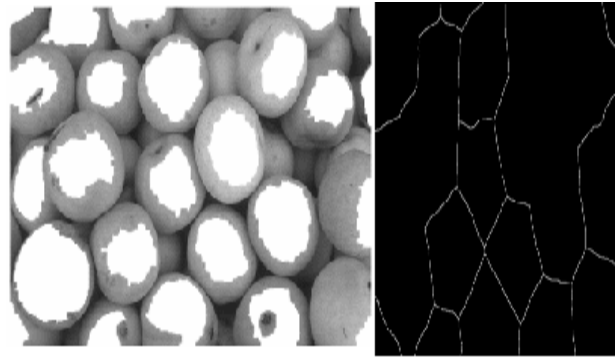
The developed segmentation method gives a resultant image, whose foreground and background markers are the objects we are trying to segment. The method is applicable to gray-scale images. Color images were first converted into gray scale. Finding the gradient image using multi scale edge detector is shown in Figure



(a) original images and (b) respective gradients.



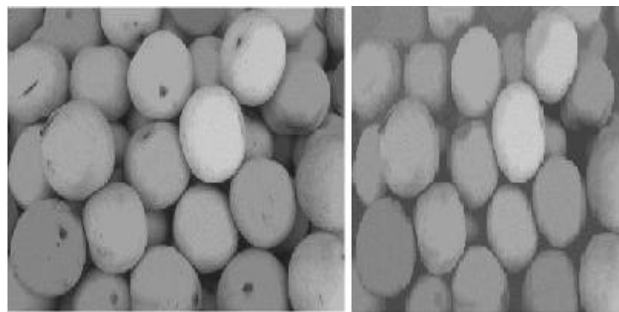
(d) Watershed transform showing over segmentation



(c) Foreground markers (objects).

(d) Background objects.

3.2. Implementation of improved watershed transform:-



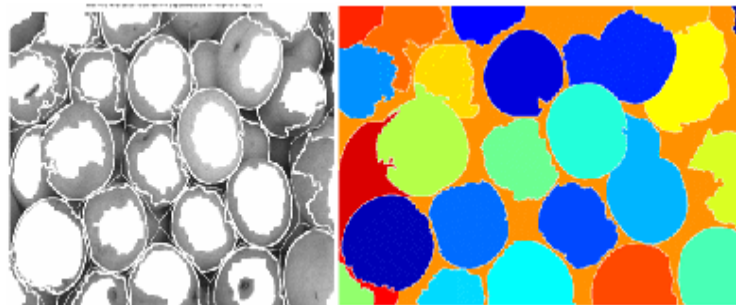
(a) erosion-based reconstruction applied on gradient images.

(b) dilation-based reconstruction applied on top images.

Calculating the regional maxima of these reconstructed images is done to get smooth edge foreground objects.

Later, we superimposed these markers on the original images as shown in Figure

Superimpose the foreground markers, background markers, and segmented object boundaries on the original image. such that object boundaries, more visible. Also Another useful visualization technique is to display the label matrix as a color image. as shown in

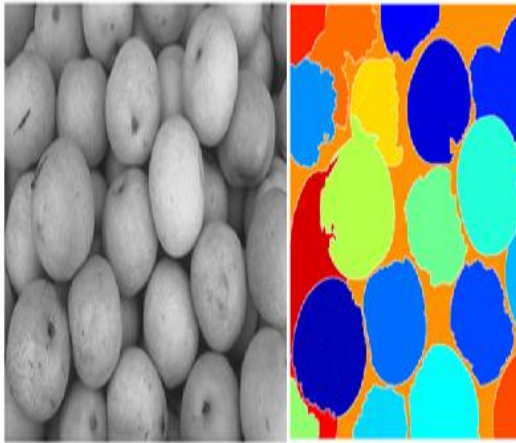


(e) Final segmented images.

(f) final color Image

Experimental Result :- The proposed algorithm applied on the aerial images and high resolution satellite images respectively. The algorithm is helpful to segment the object that touches each other in images. The proposed algorithm result gave better

identification of desired objects than the standard algorithm.



(a) original images and (b) final color Image

Conclusion and future work:-

This study shows that the proposed watershed by foreground marker is able to segment real images containing severe irregularities in a better way than the standard watershed segmentation. The formulation is based on marker and simple morphology, which easily allows a regulation of watershed and is a flexible approach for further optimization parameters and also work on improvement to the watershed transform that enables the introduction of prior information in its previous probability calculations.

References:-

- [1] Philippe Salembier, "Morphological multi scale segmentation for image coding", *Signal processing*, 38:359-386, 1994.
- [2] Malay K. Kundu, B. Chanda and Y. VaniPadmaja, "A Multi scale morphology edge detector", *Pattern recognition*, 31(10): 1469-1478, 1998.
- [3] S.J. Lee, R.M Haralick and L.G. Shapiro, "Morphological edgedetection", *IEEE J. Robot. Automat*, 3(2): 142-155, 1987.
- [4] Demin Wang, "A multi scale gradient algorithm for image segmentation using watershed", *Pattern recognition*, 30(12): 2043-2052, 1997.
- [5] Luc Vincent, "Morphological gray scale reconstruction in image analysis: Application and efficient algorithms", *IEEE Trans. On Image processing*, 2(2): 176-201, 1993.
- [6] Luc Vincent and Pierre Soille, "Watersheds in digital space: An efficient algorithm based on immersion simulations", *IEEE Trans. On Pattern recognition and machine intelligence*, vol.13, no. 6, June 1991.
- [7] Chengqun, "An edge detection method of lane line based on mathematical morphology and matlab", *IEEE* 2011.
- [8] S. Beucher and C. Lantuejoul, "Use of watershed in contour detection", *Proc Int. workshop Image processing, Real time edge and motion detection/estimation*, sept 1979.
- [9] S. Beucher, "Watersheds of function and picture segmentation", *Proc. IEEE Int. Conf. Acoustics, speech and Signal Processing*, May 1982.
- [10] Charles R. Giardina and Edward R. Dougherty, "Morphological Methods in image and Signal Processing", P-Hall, Inc., 1988.
- [11] Petros Maragos, "Tutorial on advances in morphological Image processing and analysis", *Optical Engineering*, 26(7): 623-632, July 1987.
- [12] J. Serra, "Image Analysis and Mathematical Morphology", Academic Press, Inc., 1982.
- [13] Rafael C. Gonzalez, Richard E. Woods, "Digital Image Processing", 2nd, Prentice-Hall Inc, 2002.
- [14] J. H. Ward, "Hierarchical grouping to optimize an objective function", *J. America Stat. Assos.*, 58:236-245, 1963.
- [15] K. Haris, "A hybrid algorithm for the segmentation of 2D and 3D images", Master's thesis, university of crete, 1994.
- [16] Serge Beucher, "The watershed Transformation page: Image segmentation and mathematical morphology", *cmm. Ensm*.

- [17] J. Serra, "Mathematical Morphology", Vol.1, Academic Press, London, UK,1982.
- [18] J. Serra, "Image Analysis and Mathematical Morphology", Academic Press, London, UK, 1982.
- [19] C R. Giardina and E. R. Dougherty, "Morphological Method in Image and Signal Processing", Prentice-Hall, Upper saddle River, NJ, USA, 1988.
- [20] Rafael C. Gonzalez, Richard E. Woods, "Digital Image Processing", Prentice- Hall Inc, Upper saddle River, NJ, USA, 2002.
- [21] J. Crespo, J. Serra and R.W. Schafer, "Theoretical aspects of morphological filters by reconstruction", Singal Processing, Vol.47, No.2, pp. 201-225, 1995.
- [22] J. Serra, "Connectivity on complete lattices", Journal of Mathematical Imaging and vision, Vol. 9, No3, pp. 231-251.
- [23] J. Serra and P. Salembier, "Connected operators and pyramids", in Image Algebra and Morphological image processing IV, Vol2030 of Proceeding of SPIE, pp.67-76, San Diego, Calif, USA, July1993.
- [24] L. Vincent and P. Soille, "Watersheds in digital spaces: an efficient algorithm bades on immersion simulation", IEEE Trans. On Pattern Analysis and Machine Intelligence, Vol,13, No.6, pp. 583-598, 1991.
- [25] H. Digabel and Lento Ejoul, "Iterative Algorithms", in proceeding of 2nd European symposium on quantitative analysis of microstructures in materials Science, Biology and Medicine, pp.85-99, caen, France, Oct.1977.
- [26] L. Vincent, "Morphological gray Scale reconstruction in image analysis: application and efficient algorithms", IEEE Trans. On Image Processing, Vol. 2, No.2, pp. 176-201, 1993.
- [27] D.Wang, "A Multi scale gradient algorithm for image segmentation using watersheds", Pattern Recognition, Vol.30, No.12, pp. 2043-2052, 1997.