PROGRESS IN APPLIED SCIENCE AND TECHNOLOGY
Faculty of Science and Technology
Rajamangala University of Technology Thanyaburi
Prog Appl Sci Tech. 2023; 13(1):xx-x
ISSN (Print): 2730-3012
ISSN (Online): 2730-3020
https://ph02.tci-thaijo.org/index.php/past

Research Article

Received: July 05, 2022
Revised: January 28, 2023
Accepted: February 02, 2023

DOI: 10.14456/x0xx00000x

Enhance Watershed Segmentation for Primary Medical Imaging

Chuanpit Mungkala[1*]
[1] *Department of Mathematics Faculty of Science and Technology, Rambhai Barni Rajabhat University, Chanthaburi 22000, Thailand*
*E-mail: chuanpit.t@rbru.ac.th

Abstract

In this research, we consider the problem of reducing diagnostic errors in medical imaging using an improved watershed segmentation technique. The proposed method deployed in this research depends on river basin changes and it also combines the line break method, Thresholding, and active contour method. Different shapes and operators are used for the separation to avoid changes in excess divisions in the basin. Performance measurements for image processing and watershed segmentation were made. The outcomes demonstrated that the performance of the watershed segmentation was better to that of the image processing.

Keywords: Watershed Method, Control Method, Image Segmentation

1. Introduction

Diagnosis from medical community plays a crucial role in patient's medical condition. That is, an error in medical diagnosis usually leads to wrong test results and also wrong dispensing of medicines to the patient. An example is the case of a patient in Thailand who was initially diagnosed of being HIV positive, who lived like an infected patient only to realize after ten (10) years that it was a diagnostic error [2]. Apart from the excessive medical expenses caused and the stigmatization, this has caused a great impact on the live of the patient. According to the NPSF survey, a quarter of adults in the United States (about 60 million) have revealed that they have had a wrong diagnosis in one medical circumstances or the other. The fundamental question here is, how can we the problem of diagnostic errors in medical community in this research. We address this problem using the landscape of Thailand, some mathematics tools and our knowledge of image processing. More precisely, we consider the problem of reducing errors in medical images such as cancer images, x-rays, ultrasound images in children with physical disorders and some mathematical tools in order to reduce initial medical misdiagnosis of doctors. By the first converting the original image to a graded image using a morphological method (via an on-off filter), we obtain a reference image with less noise [15]. Then we find the reference image using the water table format. Experiments with physician's image segmentation using the water table format show that image processing before and after segmentation helps to prevent grouping effectively. In this research, we analyze the accuracy of scanned images (using basic medical equipment such as X-ray imaging, ultrasound, CT scan or MRI) of diseases such as bladder stones, ovarian cysts, and brain cancer etc. To improve doctor's level of treatment. As shown in the figure 1.

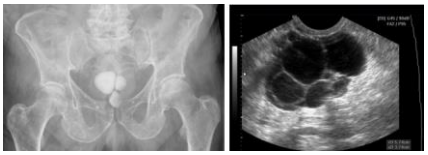

Figure 1 The images on the left and right are shown bladder calculi and ovarian cysts.

According to the information above, the difference in image processing techniques only affects the image's external look and cannot be seen inside the image. to identify picture abnormalities.

2. Materials and Experiment

Image processing is the improvement of image data to reduce unwanted image distortions or to add some image features for further processing, which is very necessary for reducing the effects of image distortion found on devices. The processing is necessary to remove unwanted areas from the image and sometimes it is used to improve the image properties such as the boundary and surface of the image. So that we can divide the image content into two parts, the desired content and not Need the ease of image for removing the noise from the image, many researchers use different. filtering techniques, depending on the type of Yong in medical imaging, all types of filter techniques may be used, depending on the noise in the image. The details are given below:

Gaussian Noise is the normal distribution of images. We don't usually see in the picture due to the white distribution.

Salt and Pepper Noise There is a characteristic It is a white spot and Black dots scattered throughout the image. White spots are caused by noise. Change the light intensity of that image spot to. The maximum value and black point is caused by the noise. Change the light intensity of that image point to the lowest value.

Poisson Noise is distribution, mean and Equal variance there is noise due to the non-linear response of the image detector and recorder. As shown in the figure 2.

Impulse Noise this is usually the result of Electromagnetic interference scratches on the recorded disc.

Speckle Noise is the presence of the observed waves. In many microscopic diffuse reflections by create obstacles to understand the composition of the image. This noise is based on the distribution of gamma found in ultrasound waves, SAR: Synthetic Aperture.

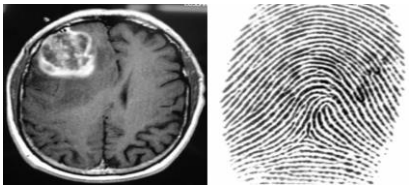

Figure 2 The images on the left and right are shown brain cancer and fingerprint.

Radar and CT scan images, De-Noising Techniques. Image segmentation is in computer vision; segmentation refers to the process of dividing a digital image into multiple segments (A set of pixels, also known as super pixels.) Image segmentation is often used to recognition, such as property search. Local suitable different from other objects and from the background the next step is to check eachpixel to see if it belongs to an object of interest. A pixel has a value, if it belongs to an object, otherwise it is zero. After segmentation, it is known that pixel belongs to which object. Therefore, Image segmentation is a part of an image in a region or category that corresponds to different objects or parts of the object. Every pixel in the image is allocated to one of these categories. Good segmentation is often one of:

Pixels in the same category have the same gray shades of multivariate values and form an interconnected region.

Neighboring pixels, which belong to different categories, have different values.

For example, in figure 2, brain cancer, each cross-section may be seen as a different object, and the successful segmentation will be groups of pixels separated by each channel. Similarly, to figure 2, the fingerprint may be seen as a separate category. Segmentation is often an important step in image analysis. Each point we move from consideration to a pixel is an observation unit working with an object. (or parts of an object) in the illustration with many pixels, if the division is good, other steps in the analysis of the image are easier. But as we can see, success is often only partially based on automatic segmentation algorithms. However, manual intervention is often able to solve these problems, and at this stage, the computer should work. The process of dividing the image into two

parts is the desired part. And other parts are unwanted the desired part is called ROI: Region-Of-Interest. In the case of brain cancer, the goal is to identify the tumor that is present in the brain cancer image. Therefore, tumors are the return on our investment and another part is undesirable areas. It is an important job for machines to automatically detect tumors due to the different surface properties of brain tissue in abnormal regions. For example, tumor return or cancer level for image segments, there are two strategies found in literature such as segmentation by border and segment by region. Segmentation-based sections are divided into.

Edge it is caused by the change in the color value of the pixels between the two regions in the image, which are the basic characteristics of the image. The dark gray color (gray scale image) has the color value of each pixel between 0-255 stored in a $m \times n$ matrix where m,n the number of rows and digits of the image is. Color Adjustment the color value for each pixel of the image is adjusted using the Gaussian filter, which creates a sub-matrix mask (mask) for filtering by using the Gaussian equation as shown in the equation 2.1.

$$G(x,y) = \frac{1}{2\pi\sigma^2} e^{\frac{x^2+y^2}{2\sigma^2}} \quad (2.1)$$

Where (x,y) is the member's position in the sub-matrix and σ^2 is the parameter value.

Gradient Magnitude: GM and Gradient Direction: GD Where (i,j) is the position of the pixel g_x and g_y is the size of the color change in the x and y direction, respectively. The values of g_x and g_y can be found in many ways, such as using the mask of the Robert Operator, the Prewitt operator or the Sobel operator. Non-maxima Suppression it is the determination of the possible cell, which eliminate non-border cells in order to check that the pixel is the highest point between the positive and negative color gradient pixels as shown in figure 3. To determine the direction of color change for each pixel from the arc tan θ value, divide into partitions 0, 45, 90 and 135 degrees by comparing the size change. The color value of the pixel considered with two neighboring pixels in the direction of change is determined. To the extent possible only if the sizes of the pixel color change value is greater than or equal to the size of the pixel color change value the left side is two pixels.

Using Double Thresholding is to specify the pixels that are border by specifying the H: High and L: Low and considering only the possible pixels. If the size of the pixel color change value is greater than or equal H, that pixel will be called a Strong edge and the dark edge will. As shown in the figures 3 and 4.

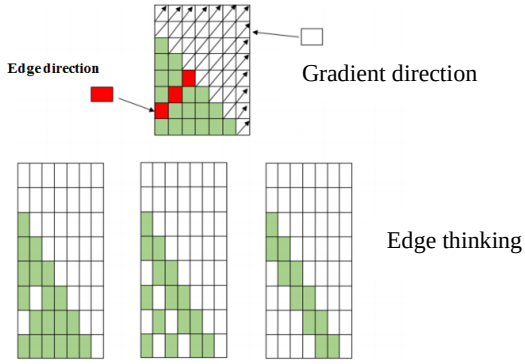

Figure 3 Images of determining possible edges.

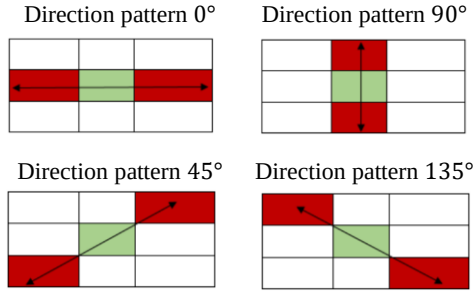

Figure 4 Image of dividing the range of the color change direction be the image.

If the size of the pixel color change is between L and H, it will separate that pixel as a weak edge and the dark edge will be the edge if at least one of the adjacent pixels is a dark edge.

If the size of the pixel color change value is less than L, then the pixel is not border If the threshold is high, some edges will not be detected. On the other hand, if the threshold value is low, it will cause edge detection errors as follows:

Thresholding is very easy to use segmentation method. Is very easy to use

segmentation method. and is a value that can be segmented. ROI is called the threshold value. In the case of a shell image and brain cancer images, we transform our images into gray images and then decide the criteria based on tumor properties, for example, we find that the tumor has an intensity of 115-255. Then we can convert all values that are less than 115 to 0 and all other values between 115-255 are equal to 1 in the Binary image. As shown in the figure 5.

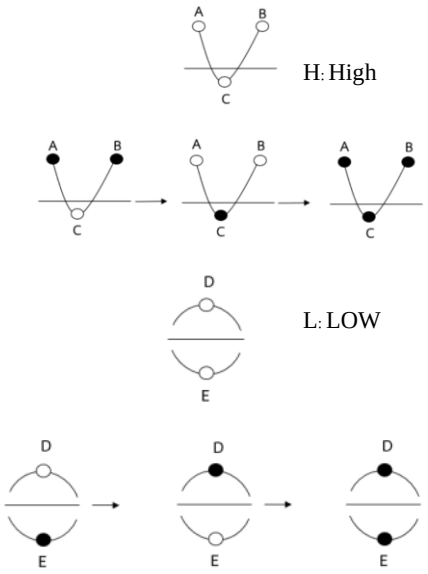

Figure 5 Image of high and low threshold value.

This method, all unwanted areas Turn black and the desired area turns white which specifies t is the pixel in position (i,j), with the grey scale $f(i,j)$ value as follows:

$$t(i,j)=\begin{cases} f(i,j)\leq 0 \\ Otherwise \end{cases}$$

Edge-based segmentation or Region Growing the growth of the region, we group the pixels or fragments of an image into a large area, meaning that we analyze the pixel values and then we combine the intensity values which are similar properties such as color, gray level value, texture and shape properties. While in the method of regional division, we take a large picture and then divide it into a small area based on the homogeneity of that region.

Region-based segmentation or clustering in feature space in the base segmentation, division of the first part of all, find the property such as average, standard deviation and surface properties such as homogeneity, entropy, relationships, and regression or wavelet parameters, then group regions based on minimum distance. As shown in the figure 6.

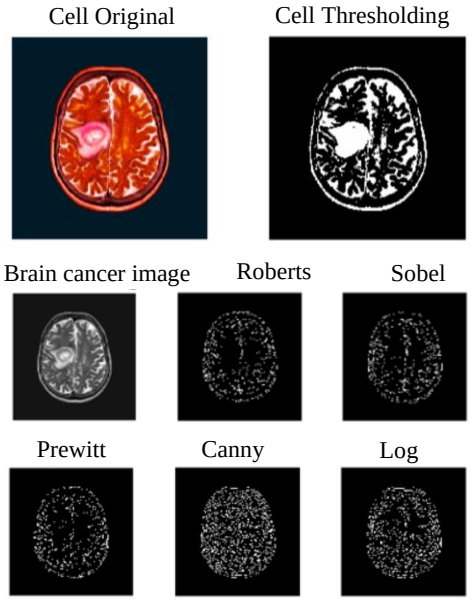

Figure 6 Image of Segmentation by Thresholding.

Grouping provides better results in medical image processing and detection of brain cancer tumors. In figure 7, grouping techniques are considered an unattended classification method in which the algorithm K-means grouping, which is famous for machine learning techniques that do not result in feature vectors that is, image segmentation is a necessary process for later image analysis. In particular, there are many techniques for captions and perceptions, depending on the grouping results very much. To divide the image into regions or objects those are elements. Segmentation of medical images in 2D pieces by piece. There are many useful programs for medical professionals such as visualization and quantity estimation of interesting objects, abnormal detection (Such as tumors, polyps, etc.), tissue volume and classification, and so on. The goal of segmentation is to make it easier and / or to

change the representation of an image into something meaningful and easy to analyze.

Generally, image segmentation is used to search for objects and boundaries (lines, arcs, etc.) in images. More accurate image segmentation is the process of assigning labels to every pixel in an image, in which pixels with the same label will Share some visual characteristics the result of image segmentation is a set of groups that covers an entire image or set of shapes separated from the image. (Edge detection) All pixels in a given area are similar to certain characteristics or calculated properties, such as color, intensity, or texture. The adjacent regions are significantly different when compared to the same characteristics. The segmentation algorithm is based on one of the two basic properties of intensity: discrete and similar. The first type is to divide the image according to the sudden change of intensity such as the edges in the image. The second type is based on dividing the image into similar regions based on predefined criteria. Histograms with the below criteria are in this category. As shown in the figure 7.

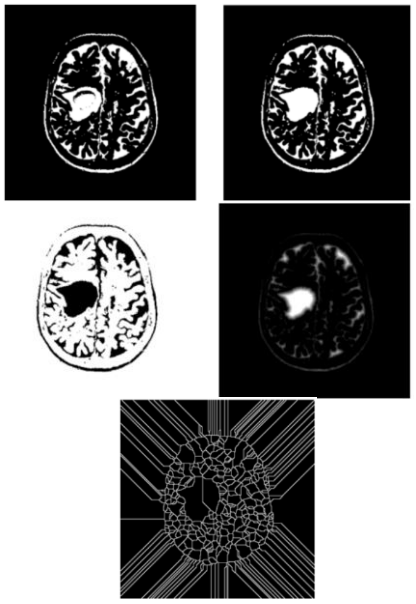

Figure 7 Image of brain cancer segmentation using Region-based segmentation method.

2.1 Watershed Method

Vincent and Soille (1991) present the classic Watershed algorithm that works on gray-scale 12 images. It uses gray as the altitude in the topology map. And every local minimum that is a basin. If water is injected into a basin, a water ridge will form in the boundary. The watershed algorithm has the advantage of closed and continuous segmentation. However, considering the magician's subtle gradation response, the sound may result in excessive division. The solution is pre-image processing to eliminate noise or flooding from the marked point instead of all images. 13 Shoji and the faculty (2005) applied the basin to the automatic lung segmentation. 14. He and the faculty (2008). Designing a SPECT lung image analysis system based on minimum cross-entropy criteria and watershed segmentation. Kanitkar and the faculty (2015) use watershed control markers to detect lung cancer. 16 Avinash and Faculty (2016) include Gabor filters, watersheds, and techniques to detect lung cancer. Basin partitioning is another regional-based approach that has its origins in mathematical morphology (Serra, 1982). General concepts are presented by (Digabel and Lantuejoul, 1978). Introduction in successful enforcement by Vincent and Soille [1991], which offer algorithmic orders of magnitude that are faster and more accurate than before. Since then it has been used extensively with a variety of medical image segmentation tasks in the basin segmentation, the image is considered to be topographical terrain with ridges and valleys. In general, the elevation value of the scenery is determined by the gray value of the relevant pixel or the slope size. From the 3D visualization, changes in the watershed will disintegrate into the reservoir. For each local minimum, the reservoir consists of all points, in which the steepest descent route ends at this minimum. The basin separated the basin from each other. Watershed transformations completely break the image and assign each pixel to the region or upstream area. With noisy medical image data creating a small amount of space, this is called the "watershed segmentation" problem. As shown in the figure 8.

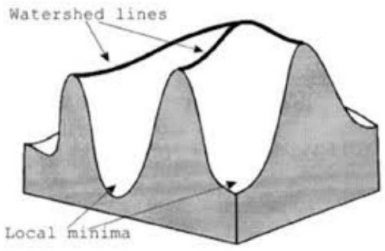

Figure 8 Image of a basin (the surface model).

Watershed marked (Marker-based Watershed) position. However, often the flow of the target structure is not checked. Therefore, users may specify the image location belonging to the target structure (including the point) or which is not the target structure (except the point). If the user specifies the combined point and the junction point, additional watershed will be created at the highest level between them. Surveyed by each region with either a collection point or a separate location but not both points this interaction model is called watershed segmentation by markers. There are many forms of river basin changes. For example, integration may consider gradient data or other criteria for homogeneity. The most commonly used variable is the combination of regions where the difference in gray values means below the threshold. This process can be repeated and the results are in a hierarchical merge map. Watershed transformation applications have been applied to a variety of segmentation tasks. Hahn and Peitgen (2000) extracted the brain with upstream transformations from MRI data. Also, the ventricles are categorized reliably with the least interaction. Hahn and Peitgen [2003] demonstrate the application to the challenging problems of individual bone separation in the human wrist. Kuhnigk et al. (2003) Segmentation for the separation of lobes and Becket (2008) uses unique conversion watershed segmentation for liver tumors. As shown in the figure 9.

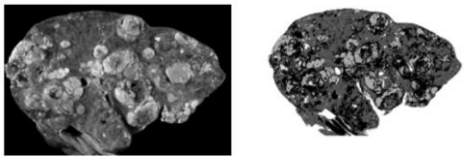

Figure 9 Image of the basin conversion for Segmentation of liver tumors.

3. Watershed Segmentation

Watershed Segmentation is Basin partitioning is an algorithm inspired by nature that mimics the phenomenon of water flowing through topographical relief. In the watershed segmentation, the image is considered to be topographical relief in which the gradient size is interpreted as altitude data. The watershed algorithm has been improved with flood control techniques to do this; the selection of marks is done automatically by separating the blobs, which is used to process the data extraction. This can be used to calculate elements such as area, eccentricity, centroid by adjusting the image in banalization using suitable criteria.

Distance Transformation is distance conversion is an operation that is generally used with binary images to separate two or more parts. The conversion results in gray scale images that are similar to the input image in shape. But the gray scale intensity of the points within the front area will vary according to the distance shown to the nearest boundary from each point, detailing the distance conversion provides an early version of the markers to begin the segmentation algorithm. However, the part may have the same color distribution, in which case we can assume that the region is the same object. The color distribution can be achieved using a color histogram. Images can be converted to matrix form, where M is the number of columns and N is the number of rows as follows.

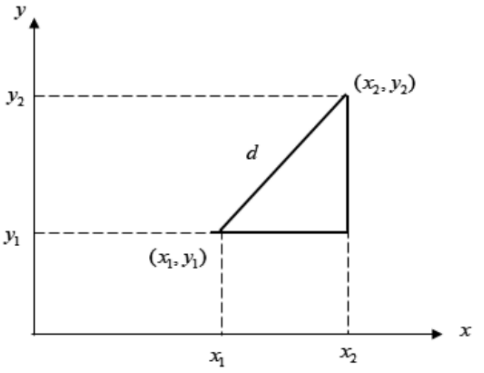

Figure 10 The Euclidean distance Transformation.

Let $(x_1, x_2) = (i_1, j_2)$ and $(y_1, y_2) = (j_1, j_2)$
By Euclidean Distance as follows.

$$f(x,y)=\begin{bmatrix} f(0,0) & f(0,1) & \cdots & f(0,N-1) \\ f(1,0) & f(1,1) & \cdots & f(1,N-1) \\ \vdots & \vdots & \cdots & \vdots \\ f(M-1,0) & f(M-1,1) & \cdots & f(M-1,N-1) \end{bmatrix}$$

The Euclidean distance Transformation can be calculated using the formula.

$$d_{Euclidean}([i_1,j_1],[i_2,j_2],)=\sqrt{(i_1-i_2)^2+(j_1-j_2)^2}$$

Gradient Magnitude is size and direction of color value changes from the following in equation 3.1 and 3.2.

$$GM(i,j)=\sqrt{g_x{}^2(i,j)+g_y{}^2(i,j)} \quad (3.1)$$

$$GD(i,j)=\arctan\left(\frac{g_y(i,j)}{g_x(i,j)}\right) \quad (3.2)$$

As shown in the figure 11.

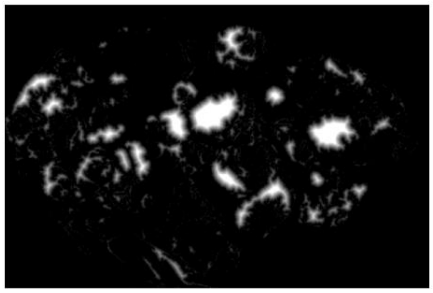

Figure 11 The Euclidean distance transformation image.

Where (i,j) is the position of the pixel g_x and g_y is the size of the color change in the x direction and y, respectively. The values of g g_x and g_y can be found in many ways, such as using the mask of the Robert Operator. Use the mask of the Prewitt operator or use the Sobel operator mask. As shown in the figure 12.

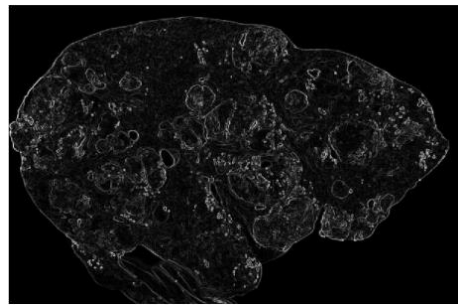

Figure 12 The gradient magnitude image.

Watershed Transform is basin changes are a popular part, methods that come from mathematical morphology. The easy to understand explanation of this change is quite simple: if we consider that the image is a relief when the height of each, the point is directly related to the gray level and considers rain gradually falling on the ground. Then, the water source is the line that separates the “lake” (actually called the basin). Watershed transformation calculations are calculated for the gradient of the original image so that the boundary reservoir is located at a high gradient. Basin changes are used extensively in many branches of image processing, including medical image segmentation. due to the gradation of the image, the effects of river basin changes are few, which makes this result less useful. The mark images are used in order to reduce the smallest number of images. Therefore, the number of regions is the most commonly used solution. The size area methods are used to select regions of interest by using different filters. Morphological operation or nonlinear distribution as shown in the picture. As shown in the figure 13.

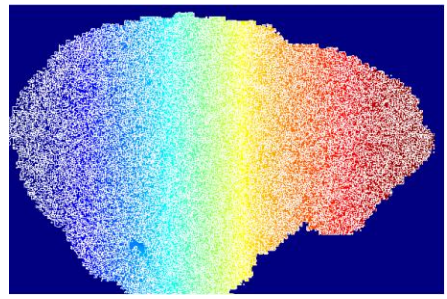

Figure 13 The gradient magnitude image.

Opening and Closing by Reconstruction is Erosion Operations and then Dilation Operations. The resulting image is an area of an image that can contain all the Structuring Element. The purpose of the opening is similar to erosion: to eliminate the area of the image, but to make the image less distorted. The result of the opening is dependent on the structure element because the opening will maintain the image that has the same shape as the structural element or can contain the structure element as shown below. in the same way Continue Dilation Operations with Erosion Operations, which are used to fill the recess to the full that the mask can be placed in the background or expand the image area (white) and reduce the background area. With a slight distortion of the shape, as shown in the figure 14.

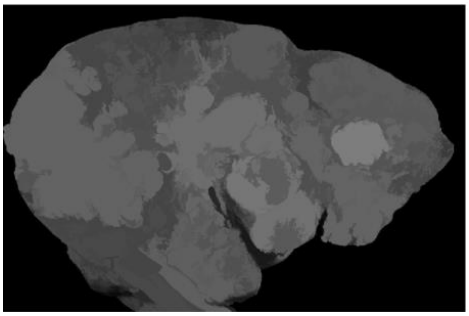

Figure 14 The Opening and closing by reconstruction image.

Threshold opening-closing is Morphological processing can be performed either in a given binary image or on a gray scalar image. There are 4 types of morphological operations: erosion, dilation, opening and closing Erosion is an eroded image created by Placement of the structural elements above each pixel of the image input.

It is new configuration to determine the pixel resolution level. Create the corresponding output pixel intensity based on logic and all pixels within this nervous system. Except that all the pixels within the neighborhood are 1 with white pixels and 0 as black pixels, the image will be eroded. Being eroded by circular structural elements, the resulting erosion shows that the properties are smaller than the structural elements. Each is removed in this case; the projection is narrow to the right will be deleted. Expansion (Dilation) is the magnification acts to enhance the erosion in the image. Magnify the output pixel to logic or all pixels within the vicinity of the input pixel. Therefore, any pixel input that has at least one white pixel image shows how the object is enlarged. As shown in the figure 15.

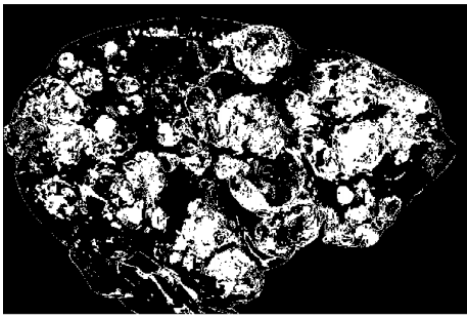

Figure 15 The Threshold opening-closing image.

Threshold opening-closing is the concept of the watershed is from the headwaters that divide the region into reservoirs. This comparison with the geographic model requires image assignment as an altitude function for the current analysis. The original image is transformed into a surface where physical altitude can be obtained from a distance map. Where distance is converted to a binary image. The distance map is obtained by replacing the value of a solid pixel with a value of 1 based on distance, measured in pixels to the closest area pixel. The shortest length, any participating path. Two pixels are calculated based on Euclidean distance. The central area of each grain will appear as a hill. The basin division is, however, the terrain was replaced by a little peak, so the water basin can be defined as a set of points with steep descending paths ending at the same local minimum in inverse values. Show distance map after being pre-processed with curvature flow filter.

And adjusted to distinguish particles Associate each pixel with the catchment basin by specifying a reduced “flow path” to the minimum or the point received then to the minimum. Soaking basin segmentation algorithm, using MATLAB image processing toolbox, this method begins with extending the boundary to the outside and up continuously, the intensity level is equivalent to the sequence of morphological operations. This limits the

accuracy of segmentation by determining the discrete gray set of levels of the image for the analysis presented here. MATLAB watershed function is applied to the inverse of each distance map of the reservoir and the value is equal to zero. Along the upstream line, however, the watershed line is the highest peak, separating the minima. The region labeled will not match the particle boundary. Therefore, a pixel with zero value (space) in the map, distance is set to the minimum value. As shown in the figure 16.

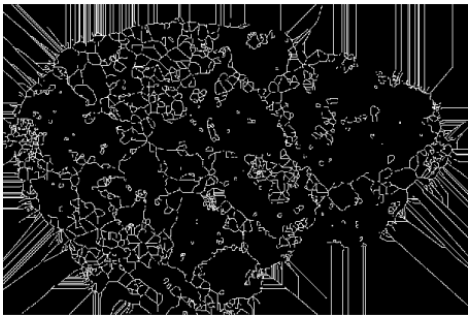

Figure 16 The Threshold opening-closing image.

Markers and object boundaries superimposed on original image is the watershed segmentation technique that uses location markers to separate the seeds that specify the existence of an object or background in a specific image position. The marker position will be set to a low level (minima) region within the topology surface. (Typically the original input color gradient) and the basin algorithm will be implemented Separation of contact objects in images is one of the most difficult images processing operations that watershed transformations often use. The watershed controlled by the use of place marks, there are two types: external related to the background and interior related to interesting objects. Image segmentation using watershed transforms works well if we can identify or" Mark" the foreground object and background-position to search" Basin" and" watershed ridge" in the image are considered to be high-light and dark pixels, low pixels as in figure 17.

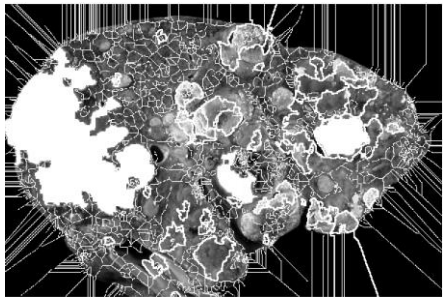

Figure 17 The Markers and object boundaries superimposed on original image.

In the research, the efficiency of the watershed segmentation is tested. We use 6 experimental images. In this research, we improve the image using Gaussian and divide the image using distance transform, gradient magnitude, watershed transform of gradient magnitude, threshold opening-closing by reconstruction and watershed segmentation. This research uses the Mathlab R2017a program and the calculation time for image segmentation by the average takes about 5-30 seconds per test image. This depends on the characteristics of the image used in the experiment.

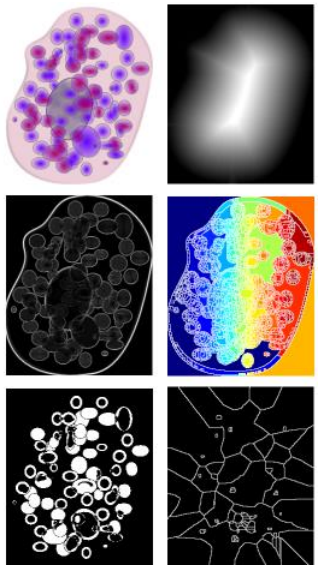

Figure 18 The cell image by Watershed Segmentation.

From the experimental results as shown in figures 19-24, the numerical analysis table was calculated from the Thresholding and watershed segmentation methods as follows:

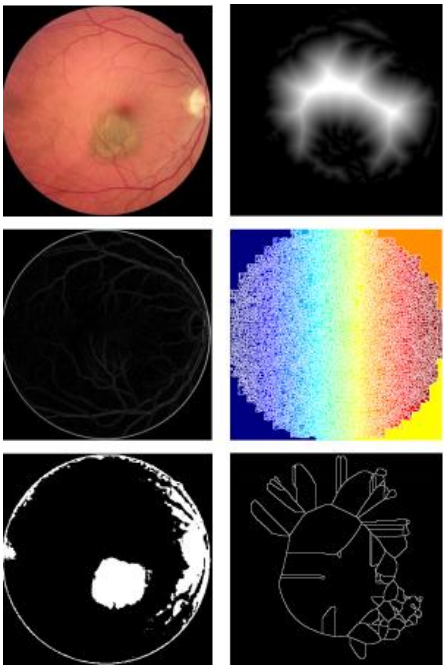

Figure 19 The eye cancer image by Watershed Segmentation.

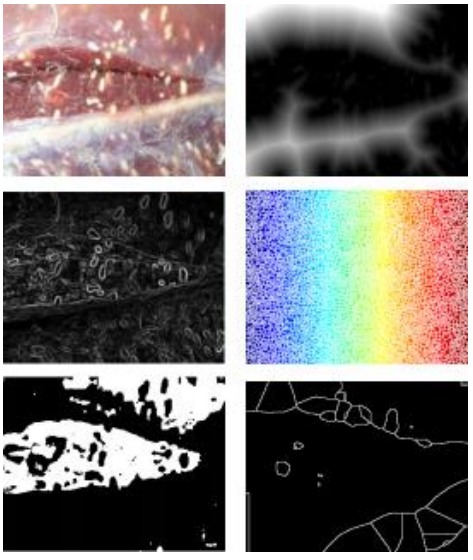

Figure 20 The Taenia saginata image by Watershed Segmentation.

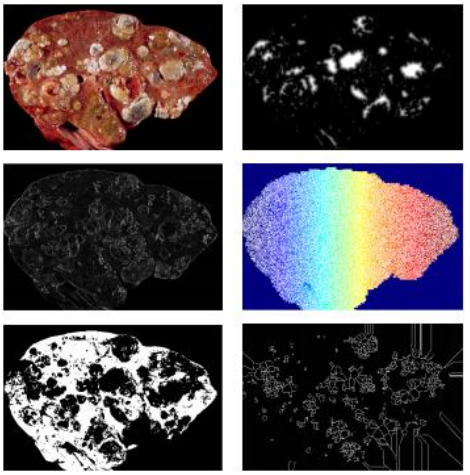

Figure 21 The liver cancer image by Watershed Segmentation.

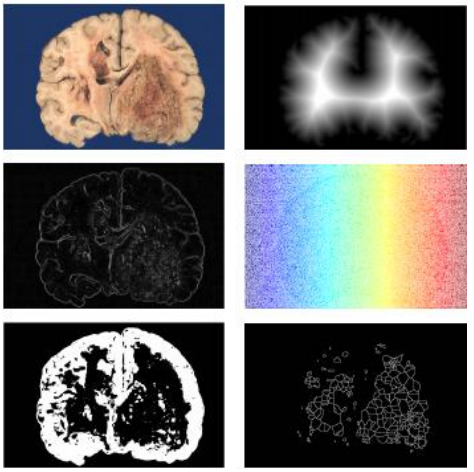

Figure 22 The brain cancer image by Watershed Segmentation.

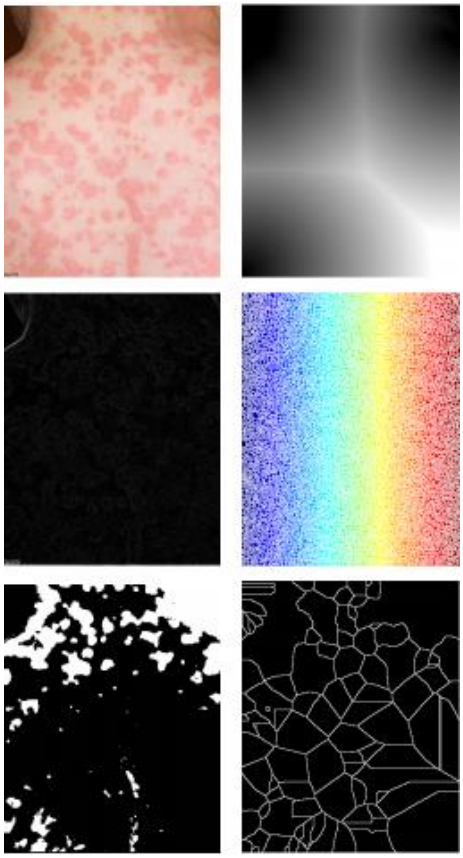

Figure 23 The sun rash image by Watershed Segmentation.

Table 1 Performance Measures of Watershed Segmentation.

Image Test	Image Processing	Watershed Segmentation
Cell	79.8945	85.9697
Eye Cancer	79.9899	86.0101
Taenia Saginata	76.8431	79.8599
Liver Cancer	78.9465	85.9788
Brain Cancer	79.9435	86.9982
Sun Rash	79.9511	86.9887

Figures 20-23 exhibit photos of cells, eye cancer, taenia saginata, liver cancer, brain cancer, sun rash, etc. We examined the structure and contrasted the effectiveness of watershed segmentation and image processing to the outcomes displayed in table 1.

4. Conclusions

In this research, a watershed segmentation method is presented. We examined, analyzed and compared images and basic medical results obtained using basin segmentation method and image processing method. The numerical results above have shown that basin segmentation method is more effective than image processing. The research has reduced the problem of blurred images, and also elimination unwanted image by using techniques to find abnormalities in the target image. The main detectable feature for accurate image comparison is the percentage of pixels and labeling with a high precision mask and efficient operation using a watershed partitioning process.

Acknowledgements

The authors were financially supported by the Research and Development Institute, Rambhai Barni Rajabhat University.

Declaration of conflicting interests

The authors declared that they have no conflicts of interest in the research, authorship, and this article's publication.

References

1. Nunes DO, erez MG. Medical Image Segmentation by Multilevel Thresholding Based on Histogram Difference. 17th International Conference on Systems. Signals and Image Processing 2010.
2. Gonzalez RC, Woods RE. Digital Image Processing. Upper Saddle River. NJ Prentice Hall 2008.
3. Tremeau A, Borel N. A Region Growing and Merging Algorithm to Color Segmentation. Pattern Recognition 1997; 7: 1191-1203.
4. Shanti L, Kadachha, Pinal J. Cancer Detection Using Modified Watershed. May 2013.
5. kaur S, jindal G. Watershed segmentation of lung ct scan images. International journal of computer and electrical engineering. December 2011.
6. Salem S, Kalyankar NV, Khamitkar SD. Image Segmentation by using Thresholding Technique. May 2010.
7. Singh KK. Study Of Image Segmentation Algorithms for Different Types of Images. September 2010.
8. Chaudhary A. Lung Cancer Detection on ct images by using image processing.

International conference on computing sciences 2012.
9. Rath M. Cancer, Cellular Health Series. February 2001.
10. Mokhled S. al-tarawneh. Lung Cancer Detection Using Image Processing Techniques. Leonardo Electron J Pract Technol 2012; 20: 147-158.
11. Zhang G, Zhou MM. Labelling watershed algorithm based on Morphological Reconstruction in Color Space. IEEE 2011; 51–55.
12. Tang J. A Color Image Segmentation algorithm Based on Region Growing. IEEE 2010; 6: 634-637.
13. Cheng L, Yan L, Shangchun FY. CCD infrared image segmentation using watershed algorithm. Third International Conference on Measuring Technology and Mechatronics Automation. IEEE 2011; 1: 680-683.
14. Zhu S, Xia X, Zhang Q. An Image Segmentation Algorithm in Image Processing Based on Threshold Segmentation. Third International IEEE Conference on SignalImage Technologies and internet based system. IEEE 2008.
15. Longzhe Q. Automatic Segmentation method of Touching Corn Kernels in Digital Image Based on Improved Watershed Algorithm. IEEE 2011; 34-37.
16. Wei Zhang. The Marker-Based Watershed Segmentation Algorithm of Ore Image. IEEE 2011; 472-474.
17. Zhang X, Chen L, Pan L, Xiong L. Study on the Image Segmentation Based On ICA and Watershed Algorithm, Fifth International Conference on Intelligent Computation Technology and Automation. IEEE 2012; 978-912.

