Journal of Basrah Researches (Sciences) **49**(2), 185 (2023)
DOI: https://doi.org/10.56714/bjrs.49.2.15

Proposed Watershed Technique Based on Whale Optimized Algorithm for Medical Images Segmentation (WAWOA)

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ARTICLE INFO

Received 31 August 2023
Accepted 26 September 2023
Published 31 December 2023

Keywords:
Image segmentation, natural inspired algorithms, watershed technique, whale algorithm

Citation: A. N. Ismael , J. Basrah Res. (Sci.) **49**(2), 185 (2023).
DOI:https://doi.org/10.56714/bjrs.49.2.15

ABSTRACT

Image segmentation is a way which applied to split an image for many parts. It will generate image smooth and easy to evaluate. A useful image segmentation technique is help the area authority in medical images. Also, a good segmented images are important in many medical fields like radiologist, pathologist of quick and successful analysis. It has used effectively in diagnosis for many disease. Nature inspired algorithms imitate the mathematical and innovative techniques for non-linear and actuality problems and can be achieved to segment or analyses the images. In this paper, a watershed as segmentation technique (WAWOA) has applied to segment the medical dataset image then proposed a whale based segmentation technique which can be used on medical bones image anyways the nature or style of the image. For fair analysis of these techniques, peak signal-to-noise ratio (PSNR), structural similarity index measure (SSIM) and Universal Image Quality Index (UIQI) of segmented images are analyzed by using MATLAB. The success of the proposed technique has confirmed with evaluated via comparing the obtained with outed results beside a standard watershed technique. The results showed this technique develops the segmentation of medical images and can help with better diagnosis. The evaluation results of our proposed technique show the success and efficiency of segmented images in high rates.

1. Introduction

Image segmentation is to exploring efficiently splitting every image into several feature regions and obtain the goal regions. One of the main aim of image processing is to restore needed data from the certain image in a method that it will not effects the new types of that image. De-noising/ improvement of an image is the most significant phase needed to meet this conditions [1]. When deleting noise from an image, you can operate every process for this image. The characteristic of segmentation mainly defines the effect of the subsequent image processing so, the color image segmentation algorithm is of large significance. Normal image segmentation methods can be

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ISSN: 1817-2695 (Print); 2411-524X (Online)
Online at: https://jou.iobrs.edu.iq

separated into three types: threshold-based, edge-based and region-based. On this base, scholars both at home and abroad have handled in- extent research on color image segmentation and applied a few results [2]. Pang et al. proposed a color image segmentation method depended on Leiyan and K6 color space segmentation and merging the segmentation regions. It beats the weaknesses of the single algorithm, but the threshold segmentation depended on foot color space in the technique is just appropriate to the color images and fewer noise and much same and good color regions [3].

Chen et al. suggested a layered color image segmentation technique. It uses together the local and global information of the image pixel. As a result, it efficiently classify a local modifications in the color image and the smaller things in the color image, and lastly realizes an acceptable segmentation result. A modern color image segmentation technique has presented by [4]. It determines together the local and global information of the image pixel. It can successfully classify all changes and important things which exist in image. Lastly, it uses to succeeds and improve suitable segmentation result.

In literature, usual segmentation techniques have been applied to classify the sections of interest from an image. Thresholding is the best applied segmentation technique because to its easiness and computational effectiveness [5]. The main clusters in the clustering based techniques involve the feature of the resulting result. The optimal solution by Fuzzy C.Means (FCM) clustering algorithm uses longer time for convergence [6]. Normally the thresholding techniques that are center about histograms cannot count spatial knowledge of an image. To exist upon the issue of not counting the spatial knowledge, were propounded but the issue of difficulty stays constant. Because of the match between the intensity values of the region of interest and background, isolation is a challenging mission and needs more computations [7, 8]

Previous research has displayed that color image segmentation algorithms depended on RGB space and Handy space are further efficient than traditional algorithms based on region, edge detection, and threshold. Though, the square RGB color space is a color space oriented to the device. There is a high association between its three color sections [9]. In addition, the nonlinear relationship between Euclidean distance and color distance has flaws, like low toughness and sluggish picture segmentation speed. The color changes provided using Euclidean distance not just meet the feeling of human eyes to image, but also correctly calculate the subtle variations between colors. [10]. Thus, in color picture segmentation, Euclidean distance denotes the various colors apparent by humans, and 6 color space is the best uniform color space regardless of tools. We present a color image segmentation technique based on current opinion which used a watershed clustering in color images using one of nature inspired algorithms. The efficiency of the proposed technique is evaluated and tested [11].To handle up with the issue of difficulty, nature inspired algorithms can be employed. The other portions of paper is additional divided as follows: second portion explains the datasets applied, whale algorithm signs concepts and the proposed technique. The third portion presents details of the evaluation and examination metrics with their particular results achieved on every technique. Fourth portion reviews the performance of the proposed technique and another standard technique. Lastly, major conclusions is discussed.

2. Watershed Technique

A common style for determining object edges is for using region growing techniques like watershed. Also, the efficiency of these techniques need to identify object signs. Therefore, depending on obtaining signs needs previous information for both things amount inside an image , particular image features and things places (e.g., medical images showed for structural outline) [14]. Also, the factors leading sign extraction manage for changing after image for image, over inspiring the use of machine learning methods for strong detection of item markers. In [15], the Bayesian sign extraction technique used a naive Bayes classifier in order to produce thing signs. Sadly, since the classifier is qualified on the ground truth defining total things, the method do not support any constraints to ensure that only one marker each goal item is extracted, nor that the obtained signs still lie in the item edge. Obviously, one can threshold the possibility map via upper rate of threshold. Significance precision will enhance at the cost of recall, and thereby pixels that match (and better possibility) to item signs may be obtained. Therefore, there is still no ensure that the will be inside item borders, nor that there will be a one-to-one similarity between items and signs. To develop site, a sign detection classifier has proposed training a marker detection classifier, marker, which achieved based ground truth. This classifier has improved and enhanced by morphological erosion [16] as explain in Eq. (1). Let

$$O_{marker} = O\ \theta\ C \quad (1)$$

Represent a corrosion of label image O in a properly indicated mechanical element D. The output of d_{marker}, represented as E_{marker} , is next known by

$$E_{marker}(i,j) = e[O_{marker}(i,j)[f(i,j)] = d_{marker}\,(f(i,j)) \quad (2)$$

Where d_{marker} is taken in the way analogous. For creating the notational difference extra evident, we henceforth represent via d_{region} and e_{region} the classifier prepared and arranged for the normal ground truth with the developing possibility map (respectively). In the trial outcomes will explain, the d_{marker} classifier is very and good conventional like better precision and littler recall with creates larger thing markers as evaluated to thresholding e_{region} by advanced values for $_T$ as in Eq. (2). Fig. 1, below shows the flow chart of Watershed technique.

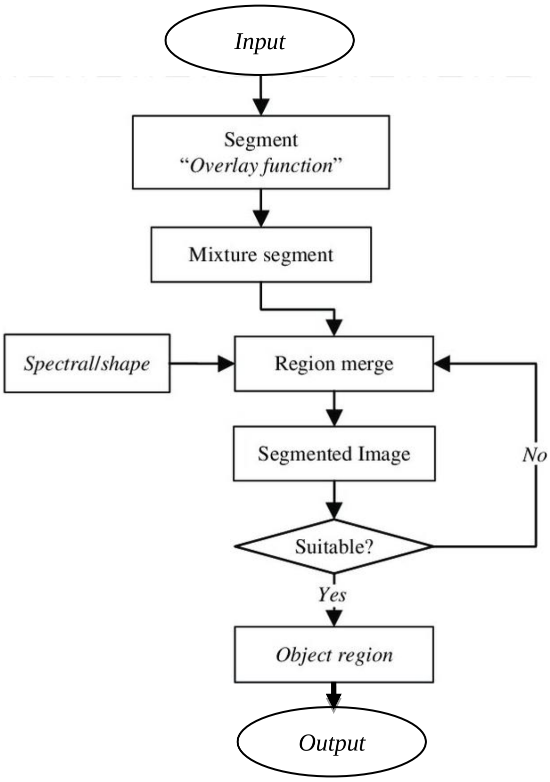

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Fig. 1. Watershed technique flow chart

3. Nature Inspired Algorithms

Nature has an important role in many human events and is a good source of inspiration. Nature Inspired Algorithms (NIAs) are such algorithms based on nature [17]. The goal of proposing NIAs is to obtain an ideal answer of the effort with incentive for search and optimization based on natural. Numerous methods, such as non-deterministic and deterministic algorithms, have been proposed and used to solve multimodal and multidimensional optimization issues over the previous two decades. Several scholars have produced a lot of proposed techniques related for image segmentation across times. it was attacked by collection for attitudes with algorithms [18]. Several optimization algorithms can be used for improve the segmentation process like the Bat Algorithm

(BA), Firefly Algorithm (FA) , Genetic Algorithm (GA) , Gray Wolf Optimizer (GWO), Dragonfly Algorithm (DA) , Moth–Flame Optimization Algorithm (MFO) ,Marine Predators Algorithm (MPA) , Arithmetic Optimization Algorithm (AOA) , Aquila Optimizer (AO) , Krill Herd Optimizer (KHO) , Harris Hawks Optimizer (HHO) , Red Fox Optimization Algorithm (RFOA) , Artificial Bee Colony Algorithm (ABC) , and Artificial Ecosystem-based Optimization .

4. Methodology

The steps of processing the data followed by proposed technique has expressed. We used one of the famous algorithm inspired by nature which name Whale optimization algorithm (WOA). Details and steps of algorithm are provided in its respective subsection**.** Lastly, dataset and proposed technique details were addressed respectively.

4.1. Whale optimization algorithm (WOA)

The WOA algorithm is inspired by the bubble-net eating of the humpback whales while they dive near of water surface with continue to swim beside a spiral-shaped lane for ruse the prey in a grid of bubbles. The WOA algorithm was statistically displayed that behavior by three techniques: encircling prey, spiral bubble-net aggressive with investigate of prey [19]. Assume Xt = (Xt 1, Xt 2, …, Xt N) as a whale population in a D-dimensional explore space such that every path Xt i = (xt i,1, xt i,2, …, xt i,D) means the location of the ith whale in iteration t. In the basic iteration (t = 1), , the matrix X1 is casually introduced in the range of problem space and for the rest of the iterations (t > 1), Xt is renewed depend or via three techniques encircling prey, spiral bubble-net aggressive with explore and investigate of prey.

4.1.1 WOA Mathematical Model

WOA studies the possibility of rate ρ for every Xt i for changing between techniques surrounding prey/ explore of prey with spiral bubble-net aggressive through optimization [20]. Besides, the quantity vector At i is measured of every whale to select between two techniques of surrounding prey with exploring of prey. Using relying on all models, the following location of the ith humpback whale Xt+1 i has calculated by Eq. (3), A possibility rate ρk i is a random value between intervals (0, 1), constant path at i has computed y Eq. (4), at i is processed by Eq. (5) linearly reduce after 2 to 0 during repetitions and rand is regular allocation between a range of 0 and 1 [21].

$$x_i{}^{k+1}\begin{Bmatrix} Encirling\ prey \quad (c^k{}_i < 0.5) and\ (|A^k{}_i\ | < 1) \\ Search\ for\ prey\ \ (c^k{}_i < 0.5) and\ (|A^k{}_i\ | \geq 1) \\ Spiral\ bubble\ net\ attacking \quad (c_i{}^1 \geq 0.5) \end{Bmatrix} \quad (3)$$

$$H^k{}_i\ = 2 \times a^h{}_i\ \times rand - a^h{}_i \qquad (4)$$

$$\mathrm{H}^k{}_i = 2 - \mathrm{k} \times \left(\frac{2}{MaxIk}\right) \qquad (5)$$

Enclosing prey method: it statistically describes the performance of humpback whales in identifying with surrounding prey that has expressed by Eq. (6), the Xk best is the location of good humpback whale, Xk i is the present location for ith whale, Dt is calculated by Eq. (7) and Ck i is calculated by Eq.(8) [22]

$$X^{k+1}{}_i\ = X^1{}_{best} - A^t{}_i\ \times D^t \qquad (6)$$

$$D^k\ = |R^k{}_i\ \times X^1{}_{best} - X^k{}_{i||} \qquad (7)$$

$$C^k{}_i\ = 2\ \times rand \qquad (8)$$

Explore for prey technique: The WOA supports a searching capability during the whale population utilizing explore for prey technique. The different location for Xk i is renewed by Eq. (7), where Xk $_{rnd}$ has at random chosen after the whale population, Ak i with Dt have calculated by Eq. (10), respectively [23].

$$X^{tk+1}{}_i = X^1{}_{rnd} - A^k{}_i \times D^k \quad (9)$$

$$D^k = |C^k{}_i \times X^1{}_{rnd} - X^k{}_i| \quad (10)$$

Spiral bubble-net aggressive technique: Spiral bubble-net aggressive technique supports searching capacity by Eq. (11), where D′ t has calculated by Eq. (12), the factor b is the form for logarithmic spiral, and l is a random number in ranges [− 1, 1].

$$X^{k+1}{}_i = D^1{}_{best} \times e^{bi} \times \cos(2I) + X^{i}{}_{best} \quad (11)$$

$$D^{ik} = |X^1{}_{best} - X^k{}_i| \quad (12)$$

While the WOA is identified famous optimization algorithm. It is a main problem related to premature merging, small population variety with disparity between explore schemes [24]. Then, because it's summary, several various WOA have been suggested for blocking its limitations. Ling et al. [25] presented the L´evy flying trajectory-based WOA (LWOA) to alleviate the low uses for prime WOA depend of little population variety and lowly explore skills. The LWOA used the L´evy flying trajectory method after the location updating to renew the locations of humpback whales. The chaotic whale optimization algorithm (CWOA) [26] used several chaotic maps like logistic cubic, sine, sinusoidal, singer and circle to utilize parameters. Also, to enhance its efficiency it uses other maps such as reaped, tent, piecewise, and gauss/mouse maps for adjusting and improve the WOA utilizing and good parameters.

4.1.2 WOA pseudocode

Including chaotic maps, using the tent map to develop for enactment ofWOA via successfully changing among investigations with operation explore schemes. An adjusted self-adaptive WOA (MWOA) [27] presented an active plan, L´evy- flying procedure with square intercalation to explain great -scale optimization problems. The MWOA equalizes investigation with operation skills by an active scheme, avoids from local goals by L´evy- flying procedure with increases the local examine via square intercalation. The (QIWOA) has performed for enhancing an investigation with operation skills by presenting a novel and modern parameter V and the square intercalation model . Figure. 2, shows Whale optimization algorithm pseudocode.

1- *Initial the whale population Xi (i=1, 2..... n)*
2- *Compute the fitness function value*
3- *Randomly choice the search agent X**
4- *While t = 1 and t < maximum iterations*
5- *for each search agent*
6- *Update a,A,C,t, and p*
7- *If 1 (p <0.5)*
8- *If2 (/A/<1)*
9- *Update the position the current search agent by the equation (8)*
10 *– Else if2 (/A/) ≥1)*
11- *Update the position the current search agent by the equation (9)*
12- *End if2*
13- *Else if1 (p ≥ 0.5)*
14- *Update the position the current search agent by the equation (10)*
15- *End if2*
16- *End for*
17- *Check if any search agent goes beyond the search space or else ament it*
18- *Compute the fitness function value*
19*-Upfdate X* if it is batter*
20- *t = t+1*
21- *End while*

Fig. 2. Pseudo code of whale optimization algorithm (WOA)

4.2. Dataset

A dataset which used in this study are collected from hospital and its medical departments. To evaluate and approve the segmentation technique on several medical images regardless of its type or modality, we considered 15 images of medical images especially the bones images. For every image, the size 600*600 pixels has be used with JPEG format. The dataset which adopted and used is taken from X –ray department in Al-fayhaa hospital which is located in Basrah city. The experiment results are archived in the software MATLAB R2022b, with operating system Windows 10. The some samples of dataset images are depicted in Fig. 3.

Fig. 3. Samples of dataset

4.3 Proposed Technique (WAWOA)

In this study, we proposed a watershed image segmentation technique based on whale nature-inspired algorithm foe medical images (WAWOA) which uses optimal value for discovering enhanced segmentation. The gray image's histogram has defined a connection between the gray values of every level for digital image with its frequency of existence. The histogram uses in expressing an amount of pixels in every with all gray levels for image. However, it not uses to epitomizing each image. We are eternally searching for good ways that enhancing the performance of technique through parameters choice. Therefore, WAWOA changed the color image to gray measure image. The evaluating the enactment of segmentation technique employing important measures of quality which are the Peak Signal to Noise Ratio (PSNR), Structural Similarity Index Matrix (SSIM) and the Universal Image Quality Index (UIQI) . The proposed algorithm phases have displayed in Fig.4.

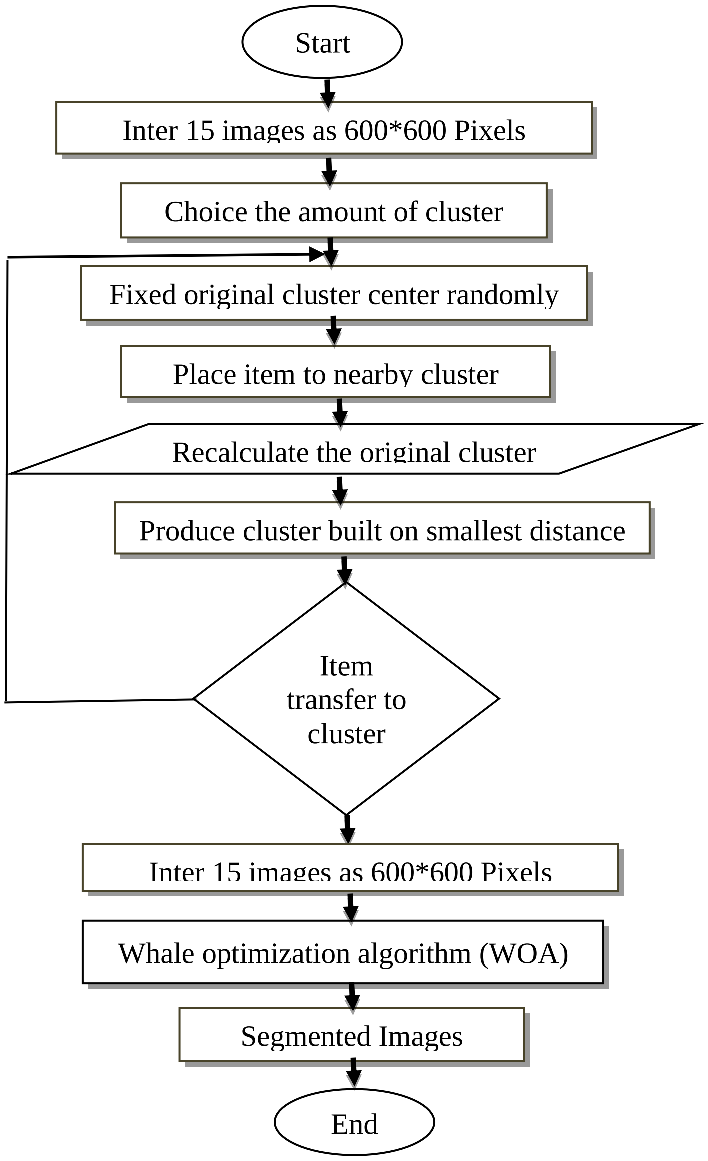


Fig. 4. (WAWOA) steps chart

5. Experimental Results

The WAWOA compared with watershed algorithm of medical images as data sets. The evaluation has been conducted based on three measures, namely, PSNR, SSIM and UIQI based on Eq. (13), Eq. (14), and Eq. (15) respectively. The reason for selecting these measures is their common usage in image segmentation. Table 1 summarizes the equations used for the quality validation metric of each segmentation. Also, a samples of segmented images by proposed technique and watershed technique are showed and explained in figure below.

$$PSNR = 10\ log_{10}\left(\frac{MAXi}{\sqrt{MSE}}\right) \qquad (13)$$

$$SSIM = \frac{(2uxuy+c1)(2\partial xy+c2)}{(u2x+u2x+c1)(\theta_x{}^2+\theta_y{}^2+c_2)} \qquad (14)$$

$$UIQI = \frac{u\theta vx + u2vy\ \theta 2vi + \theta 2vx\ \ \theta v2\theta v2\ 4\theta xyXY}{(\theta 2x + a2x)[(x)2 + (y)2]} \qquad (15)$$

Watershed Technique

WAWOA Technique

Fig. 5. Samples of Watershed technique and proposed technique for segmented images

From the scores in the table Table 2, we can see that PSNR has the biggest deviation to the scores made by our proposed technique. SSIM includes image structure information in its image quality metric. Therefore, SSIM has much better performance than that of SSIM which generated by standard watershed technique. Since WAWOA metric considers both global and local information of an image, its performance scores are better by UIQI values from normal technique as showed in tables. From the scores in the tables, the overall performance of WAWOA is the best of the all image quality evaluation when comparing with watershed technique.

Table 2. The WAWOA and watershed PSNR, SSIM and UIQI values.

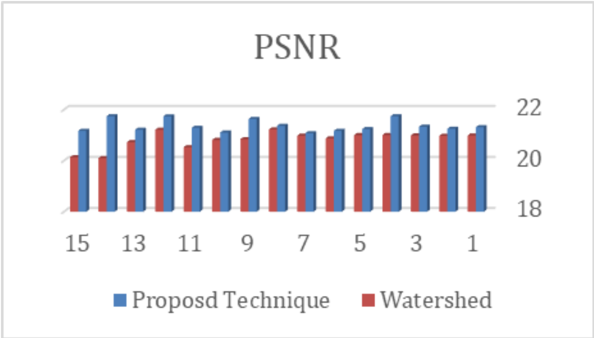
Watershed Technique

ImNo	PSNR	SSIM	UIQI
1	20.9845	0.5806	0.8989
2	20.9709	0.6181	0.9191
3	20.9884	0.6001	0.8908
4	21.0042	0.5834	0.9124
5	20.9998	0.5930	0.9324
6	20.8695	0.6003	0.8912
7	20.9782	0.6133	0.8895
8	21.2220	0.5897	0.8234
9	20.8400	0.5958	0.9234
10	20.8123	0.5912	0.8966
11	20.5270	0.6116	0.9711
12	21.2110	0.5984	0.9344
13	20.7231	0.6110	0.9523
14	20.0984	0.6065	0.9342
15	20.1354	0.6113	0.9233

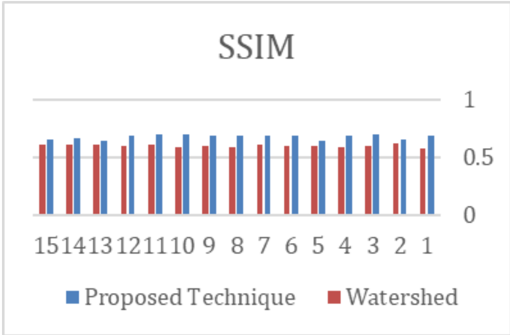
Proposed Technique (WAWOA)

ImNo	PSNR	SSIM	UIQI
1	21.3108	0.6896	0.9429
2	21.2400	0.6589	0.9520
3	21.3278	0.6990	0.9763
4	21.7375	0.6869	0.9733
5	21.2333	0.6432	0.9942
6	21.1662	0.6897	0.9498
7	21.0745	0.6895	0.9123
8	21.3634	0.6867	0.9096
9	21.6332	0.6908	0.9643
10	21.1002	0.6980	0.9409
11	21.2870	0.7005	0.9971
12	21.7344	0.6861	0.9876
13	21.2093	0.6438	0.9842
14	21.7410	0.6627	0.9899
15	21.1673	0.6543	0.9961

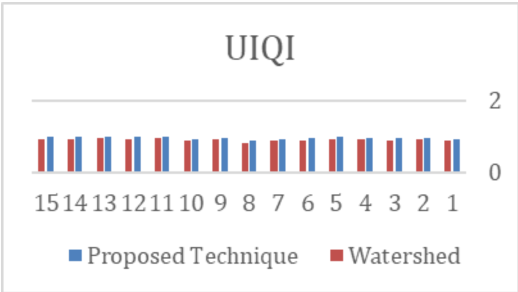
The next Fig. 6(a) it is observed that the performance of WAWOA was higher in terms of PSNR levels. It recorded a good and better values for segmented images. It is observed that the standard Watershed technique lower values for all images. In turn, for the SSIM and UIQI measures. The fig 6(b) and (c) show the results achieved for the segmentation using 15 images. From these figures, it can be determined that proposed technique has generated a higher SSIM and UIQI values. Finally, the proposed technique WAWOA obtains the best values in terms of PSNR, SSIM and QIUI when it compared with standard technique. In addition, the next fig 7 shows that proposed technique WAWOA has enhanced the PSNR, SSIM and QIUI values when compared with standard watershed technique as in in its three parts (a), (b) and (c) respectively.



a

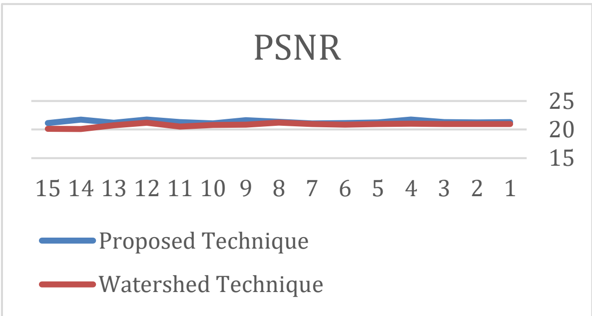


b

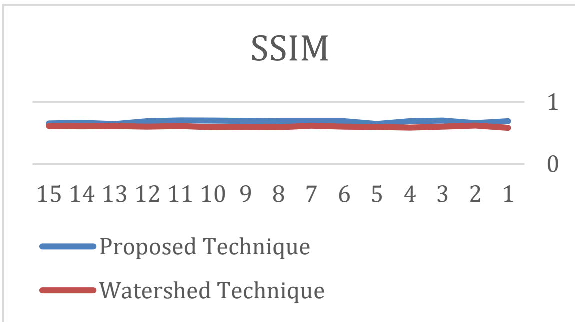


c

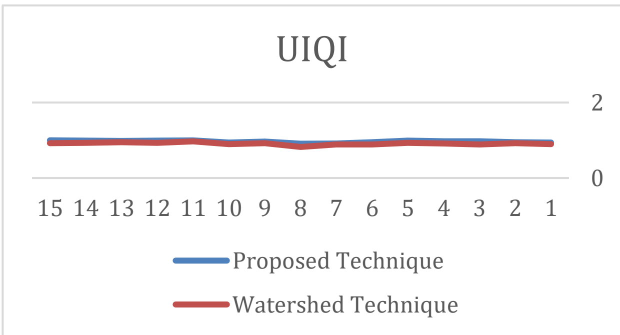
Fig. 6. Experimental results obtained using medical images with the Watershed technique and proposed technique (WAWOA)



a



b



c

Fig. 7. Experimental results obtained using medical images with the Watershed technique and proposed technique (WAWOA)

6. Conclusion

We detected the applications which related for images segmentation in image medical. Contrast of several medical images can be developed by using several ways .Whale optimization algorithm is one and famous of the commonly applied optimization approach since of its excellent performance. In this paper, a watershed technique built by whale optimized algorithm is name WAWOA has proposed to develop medical images segmentation. It used the whale algorithm parameters to optimize standard watershed technique for segmenting images. It used the 15 real medical images for bones as dataset for segmentation. Three evaluation measures have used to evaluate the WAWOA performance which are PSNR, SSIM and UIQI. The experimental results appear that our proposed technique has more effective in accurate way for segmenting and it produced a better values when comparing with standard technique. Experimental results showed that the proposed technique not just overcomes images problems effectually, but and protects its backgrounds. This technique can be used to develop various medical images that can help medical specialists with well diagnosis and treatment which are important to advance public health.

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Journal of Basrah Researches (Sciences) **49**(2), 185 (2023)
DOI: https://doi.org/10.56714/bjrs.49.2.15

تقنية مستجمعات المياه المقترحة بناءً على خوارزمية الحوت المُحسّنة لتجزئة الصور الطبية

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معلومات البحث

الاستلام 31 اب 2023
القبول 26 أيلول 2023
النشر 30 كانون الأول 2023

الكلمات المفتاحية

تجزئة الصور، الخوارزميات الطبيعية ، تقنية مستجمعات المياه، خوارزمية الحوت

Citation: A. N. Ismael , J. Basrah Res. (Sci.) **49**(2), 185 (2023).
DOI:https://doi.org/10.56714/bjrs.49.2.15

الملخص

تجزئة الصورة هي طريقة يتم تطبيقها لتقسيم الصورة إلى أجزاء عديدة. سيولد صورة سلسة وسهلة التقييم. إحدى تقنيات تجزئة الصور المفيدة هي مساعدة سلطة المنطقة في الصور الطبية. كما أن الصور المجزأة الجيدة مهمة في العديد من المجالات الطبية مثل أخصائي الأشعة وأخصائي علم الأمراض للتحليل السريع والناجح. وقد استخدم بشكل فعال في تشخيص العديد من الأمراض. تحاكي الخوارزميات المستوحاة من الطبيعة التقنيات الرياضية والمبتكرة للمشكلات غير الخطية والواقعية ويمكن تحقيقها لتقسيم الصور أو تحليلها. في هذا البحث، تم تطبيق تقنية تجزئة مستجمعات المياه لتقسيم صورة مجموعة البيانات الطبية ثم اقترحت تقنية تجزئة تعتمد على الحوت (WAWOA) والتي يمكن استخدامها في صورة العظام الطبية بغض النظر عن طبيعة الصورة أو نمطها. للحصول على تحليل عادل لهذه التقنيات، يتم تحليل نسبة ذروة الإشارة إلى الضوضاء (PSNR)، وقياس مؤشر التشابه الهيكلي (SSIM) ومؤشر جودة الصورة العالمي (UIQI) للصور المجزأة باستخدام MATLAB. تم تأكيد وتقييم نجاح التقنية المقترحة من خلال مقارنة النتائج التي تم الحصول عليها والنتائج المعلنة بجانب تقنية مستجمعات المياه القياسية. وأظهرت النتائج أن هذه التقنية تعمل على تطوير تجزئة الصور الطبية ويمكن أن تساعد في التشخيص بشكل أفضل. تظهر نتائج تقييم التقنية المقترحة نجاح وكفاءة الصور المجزأة بمعدلات عالية

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ISSN: 1817-2695 (Print); 2411-524X (Online)
Online at: https://jou.iobrs.edu.iq