A Survey of Image Segmentation Based on Soft Computing Approaches

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Abstract

Image segmentation is an essential step in image processing, that aim to make image analyzing easier. Image segmentation can be done by grouping or partitioning the image pixels into identical sets (regions) by relying on some qualities such as color, or texture, etc. It's have been used in many field such as object detection, recognition tasks, medical imaging and much more. there are basically two primary approaches for image segmentation which are traditional approaches and soft computing approaches (SCA), a lot of methods have been proposed based on these two approaches. SCA have many advantage over traditional approaches like flexibility, cost-effective, high performance. SCA involve using fuzzy logic, Artificial Neural Network (ANN) and Genetic Algorithm. This paper focus on providing a state-of-the-art new review and summaries of researchers' work on image segmentation based on different SCA. That will help the new researchers to learn about these methods and then choosing a certain method from these for improving or developing it to produce a new method for image segmentation.

Keywords: - Image Segmentation, Soft computing, Fuzzy logic, Neural network, Genetic algorithm

I. Introduction

An Image can store a lot of useful information. A digital image composed of a finite number of elements (these elements also known as pixels or picture/ image elements), each element has a particular value and location. pixels are the smallest single element in the image, retaining a finite, discrete, quantized values that represent the brightness, intensity or gray level at any specific point [1]. Understanding the image and extracting data from it to do specific tasks is a key area of application for digital image technology, and image segmentation is the first stage in this process.

Image segmentation considered as one of the fundamental steps in image processing [2], it attempts to automatically analyze or interpret an image. Segmentation fill the gap between low-level and high-level image processing [3], as shown in Figure 1. So image segmentation can be defined as the

process of dividing an image into several segments based on particular characteristics including color, texture, and intensity values etc, and that's done in order to transform the image's representation into something more meaningful and easier to understand (similar in term of properties, attributes and features). It genuinely locates an image's objects and bounds. The degree to which this division is carried out is determined by the problem being solved; segmentation should finish once the application's objects of interest have been isolated. So Segmentation is a technique for converting a complicated image into a simpler image [4] [5].

There are many applications of Image segmentation, such as medical imaging (medical diagnosis, locate tumors and other pathologies, etc.), content based image retrieval, Recognition tasks(recognition of Face, fingerprint, Iris),Machine vision, industrial inspection, object detection (like detecting roads and bridges in satellite images, Face detection, etc.), and more [5].

Image segmentation can be accomplished using a variety of approaches. Traditional approaches and soft computing approaches. Traditional approaches are straightforward and easy to implement methods. They achieve and produce precise answers to the segmentation problem. Traditional approaches are usually classified into four categories based on how they work: (1) region-based segmentation, (2) clustering, (3) edge-based segmentation, and (4) thresholding. These approaches are inefficient because they cannot handle real-world complicated situations that tolerate partial truth, imprecision, uncertainty, and approximations; they are also time-consuming, inefficient, and labor-intensive.

As a result, Soft Computing approaches(SCA) are utilized to address such issues. Soft Computing's objective is to create artificial intelligence by replicating a human brain's reasoning capabilities to solve ambiguity or real-world complicated situations. Soft computing(SC) combines computing techniques with biological structures to create new methods for more dynamic, competent, and dependable solutions. SC is a collection of techniques that includes fuzzy logic (FL), artificial neural networks (ANN), and genetic algorithms (GA). SC approaches, unlike traditional approaches, are forgiving of imprecision, uncertainty, partial truth, and approximations. Working with their ownership function gives them greater freedom, which makes them more powerful. SCA are widely employed and valued by researchers because of their adaptability and accuracy. SCA have the added benefit of being cost-effective, high-performing, and dependable solutions to

difficult issues. SC techniques have been used in a variety of fields, including scientific study, medicine, engineering, and management.

So, the contribution of this paper is to provides review and summaries of researchers' work on image segmentation based on different soft computing approaches (SCA). The goal is to bring together various aspects such as new techniques, emerging topics for segmentation depending on SCA, evaluation parameters, problems associated with it, future plans, and other resources so that researchers can focus on developing new methods for various image segmentation applications [6].

This paper is organized as follows, Section II, is focused on Review some of the new works in image segmentation based on different soft computing approaches. Section III presents the conclusion for soft computing approaches to image segmentation. Finally, the references are given in Section IV.

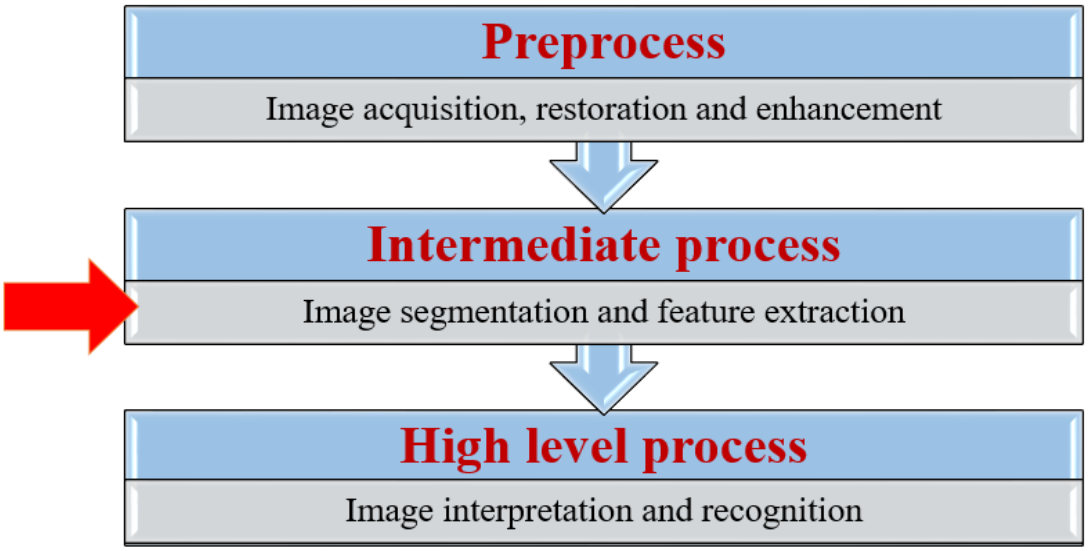

Figure 1: Element of image Analysis

II. Soft Computing Approaches

For comparison, three different soft computing approaches to image segmentation are most commonly used. These are (1) Fuzzy based approaches, (2) Genetic Algorithm based approaches, and (3) Neural Network based approaches. The following are the specifics of Approaches:

1. Fuzzy based Approach

It is based on the degree of truth or falsehood principle. It's a probabilistic segmentation method based on a fuzzy logic framework. The input image is first fuzzified, then passed on for membership modification based on expert knowledge and a set of fuzzy logics and set theory. The final result is

achieved after passing the modified image through image defuzzification, Figure 2, show the general structure of fuzzy system. Fuzzy thresholding, fuzzy integral-based decision making, and fuzzy c-means clustering are examples of fuzzy-based approaches [7]. The summary of fuzzy logic(FL) newest articles are shown in Table 1.

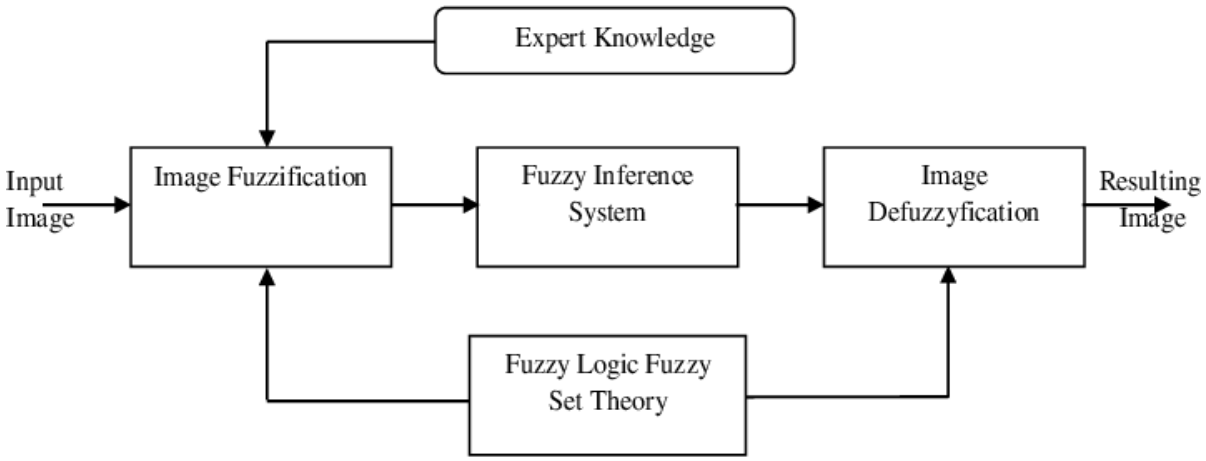

Figure 2: General structure of fuzzy system

Table 1: summary of FL newest articles

Ref	TECHNIQUE/ methodology	Parameter	Domain	Data set/ Result
[8]	**Fuzzy Entropy and improved Intelligent optimization algorithm**	$n_{eb} = n_{ob} = 50. K = 100. M = 100$	**Binary and Grayscale images**	**Various images/ six functions are used to test reliability of chaos bee colony particle swarm optimization (PSO)**

				and PSO algorithm. Mean value and standard deviation also used. The proposed algorithm has good performance in aspect of evolution result quality, convergence speed and stability.
[9]	**Active Contours and Fuzzy Logic**	$\lambda_1 = \lambda_2 = \mu = 1.\kappa = 2.\ \rho = 3.\Delta t = 0.1.u_1 = v_1 = 3.w_1 = 0.02 \times (255)^2$	**(Water and Land) synthetic aperture radar (SAR) image**	**SAR image of the Ajkwa river/ PRI and GCE were used for result validation. The proposed technique offers better computational efficienc**

				y and accuracy compared with the RSF model
[10]	Fuzzy Clustering	Iteration (100, 200, 300 and 400)	brain tumour image (MRI images)	global databases of brain tissue images (MRI images)/ the proposed algorithm technique correctly (accurate) detecting brain tumor. it can distinguish the brain tissue of the three regions (WM, WG and CSF).
[11]	Fuzzy Set and Thresholding	image gradient (High Pass Filter and mean filter (hpf and mf)) and thresholding filter	Mammography Images Segmentation	database (mini-MIAS)/ the proposed method produce

				d higher (CDR and DSI) values When compared to Sensitivity. The fuzzy set improved the accuracy of segmentation.
[12]	**Fuzzy C-mean (FCM)) and K-mean (K-MEAN)**	**for k-means algorithm:- no. of clusters (=6), number of Iteration (≤100). for Fuzzy c-means algorithm:- no. of clusters (=6) and maximum number of Iteration (=100).**	**Mammography Images Segmentation**	**mini MIAS database / the accuracy of FCM algorithm is 94.12% which is higher than the accuracy of k mean algorithm that is 91.18%. While k mean method is less time consuming to implement than the FCM**

				method.
[13]	**iterative type-2 fuzzy C-mean (IT2FCM)**	m_1**=1.1,** m_2 **=5.0**	**MRI images on a massively parallel SIMD architecture**	**medical images from a large database / IT2FCM has a higher accuracy level than the FCM. but it is costly in terms of processing time. the results show that the proposed PIT2FCM 1 significantly improves execution time over the PIT2FCM 2. PIT2FCM 1 appears to be best in accuracy and execution time results.**

2. Genetic Algorithm based Approaches

A genetic algorithm is a method for computing, it is an algorithm for searching optimal solutions. by modeling the biological evolution process through natural selection and genetic mechanisms. It creates individual populations, determines individual fitness, and selects regenerative individuals, crosses, and mutates to create new individuals based on fitness. It features a high level of robustness, parallelism, adaptability, and speed of convergence. It can be used to determine the segmentation threshold in image segmentation technology [14]. Image segmentation using genetic algorithm shown in Figure 2. The summary of genetic algorithm (GA) newest articles are shown in Table 2.

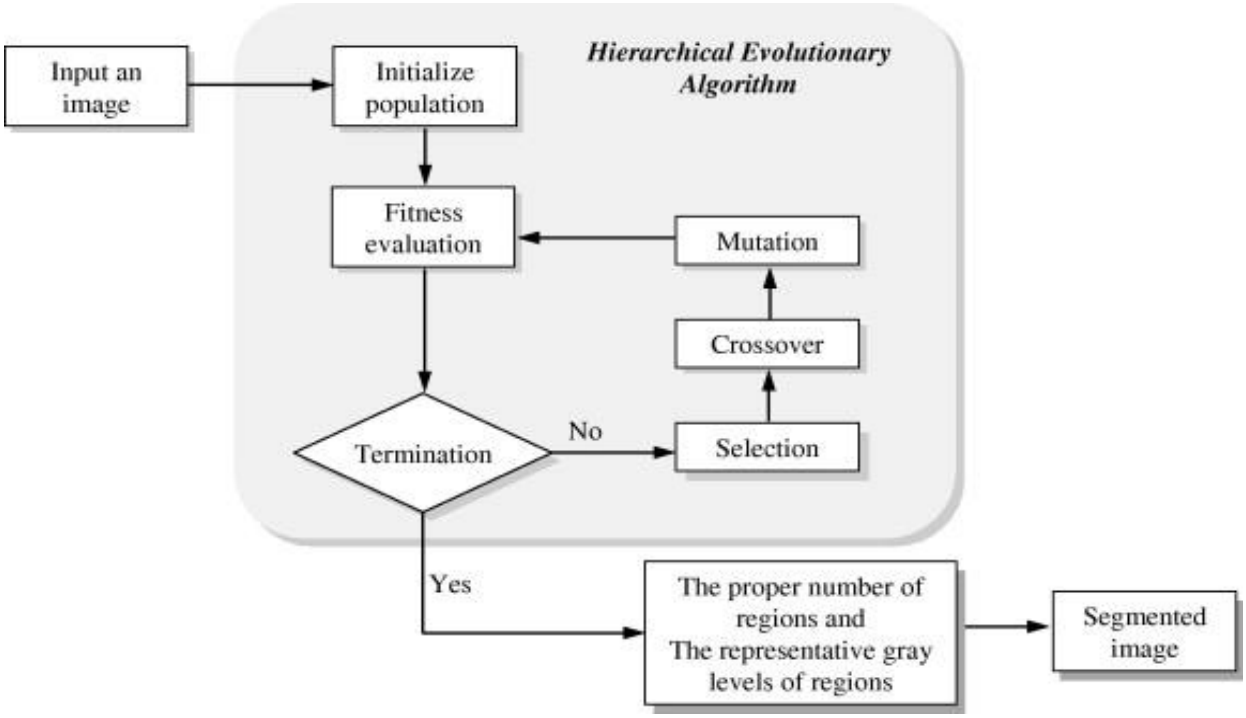

Figure 2: Image segmentation using genetic algorithm

and here is a review of some newest previous studies for this method.

Table 2: summary of GA newest articles

Ref	TECHNIQUE/ methodology	Parameter	Domain	Data set/ Result	FUTURE WORK
[15]	An improved OTSU method based on Genetic Algorithm	**Initialization: -** 10 populations, optimal threshold range [$T1$, $T2$]. individual fitness: $\sigma 2(kk)$ **Mutation:-** Hamming distance $H_{i,j}$ length of the binary number n = 8. mutation rate P_m $f.f_m.f_a.\ H_a.H_m$	gray scale images	two gray scale image / The improved Otsu approach can reduce calculation time in the long run	accelerating this method
[16]	Maximum Entropy and Genetic Algorithm	**Initialization: -** 20 population, max.no. iteration=100 probability	foreign fiber in cotton images	different foreign fiber images / The proposed algorithm is more accurate than the standard Otsu	Improving the accuracy of the proposed algorithm for detection

		of the individual P_i Crossover probability:- P_c is 0.8 during the first 50 generations of the evolution P_c is 0.6 in second part of the evolution **Terminate Criterion:-** Max.no.iterations min.no. iterations =10 min value ε = 0.0001		approach, and its speed is rapid and adaptive.	of white foreign fibers (such as plastic sheeting, plastic film, etc.)
[17]	genetic algorithm and entropy	population size $p = 30$ and the chromosome length $m = 50$ The stopping condition is based on the maximal number of generations which set to 300.	medical and real world images	medical and real world images with different histograms and sizes / PSNR and RMSE are used to evaluate the suggested method which maximizes entropy (by using Tsallis	expanding the work For segmentation and edge detection by considering other entropies and a large sample of real- world and

				and Renyi entropies) and produces better image segmentation quality than the standard thresholding strategy. The result show that Renyi entropy provides better image segmentation quality.	synthetic images
[18]	Improved Fuzzy C-Means Based on Genetic Algorithm	Max.no. iterations T, termination threshold ε =100 and -10^{-5}, weighted index $m = 2$ membership S-FCM algorithm suppression parameter α =0.9, GFCM convergence speed parameter α =0.9, PFCM algorithm parameter a =1, b	synthetic, simulated and real medical images.	synthetic, simulated, and actual medical images / The results suggest that the robustness to noise of the new image segmentation is significantly improved by GA.	Nil

		=1, η =2.			
[14]	Genetic Algorithm	The object is Palm (256*256) image, the initial population number is set to 20, the crossover probability P_c is 0.8, the mutation probability P_m is 0.03, and the maximum evolution algebra T is 100.	Palm (256 * 256) image .	Palm (256 * 256) image / the genetic algorithm is utilized as an optimization algorithm in image segmentation, which reduces the time required to find the threshold. The effect of image segmentation using a genetic algorithm is superior to standard image segmentation, it also offers strong stability and enhances convergence speed.	Nil
[19]	Hybrid Genetic Algorithm with Particle Swarm	length of chromosome m = 50, size of population p = 30, max generation	practical and medical image	various image kinds / PSNR and MSE are used for result validation. the proposed	Nil

	Optimization and Entropy (GA-PSO and Renyi, Tsallis entropies)	count=300 The thresholding rate pairs (t*, s*)	samples	method proficiently increases entropy and produces improved image segmentation quality when compared to the conventional thresholding method	
[20]	modified Genetic Algorithm (GA) by k-means algorithm	Nil	cell blood images from micro scope	set of cell blood images / PSNR and MSE are used for evaluating the performance. PSNR for the proposed algorithm is higher than other algorithms.	Nil

3. Neural Network based Approaches

The nervous system of a human processed information in the same way as a "Artificial neural network (ANN)" did during image processing operations. The weights between the layers of the network, also known as interconnectivity, are changed so that the network can learn or understand the knowledge. When the network has fully grasped or been trained on the knowledge, it is capable of determining the best solution output for the set of input data. Generalization is the most significant property of neural networks [21]. The architecture of artificial neural network illustrated in Figure 2. The summary of neural network (NN) newest articles are shown in Table 3.

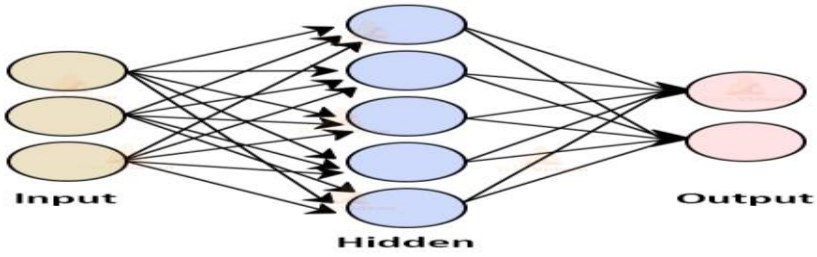

Figure 3: Architecture of Artificial Neural Network

Table 3: summary of NN newest articles

Ref	TECHNIQUE/ methodology	Domain	No. of convolutional layer	No. of Maxpooling/ average pooling/ sample	Filly connected layer	Softmax classifier/ output layer	Type of classification rectifier/ cost function/ activation function	Training using BPA or SGD/ other parameters	Data set/ Result/ Future work
[22]	convolution neural network (CNNs)	brain tumor image segmentation	2C (18*28) 2C (12*12) 1C (5*5)	2S (28*28) 2S (12*12) 1S (5*5)	1F (28*28) 1F (12*12) 1F (5*5)	1 output layer	Rectifier linear units (ReLU)	Combing forward and backward propagation (BPA)	datasets BRATS 2013 / Dice ratio (DR) is used for evaluation the proposed method, CNNs accuracy is better than other methods like (Bauer and Menze).
[23]	Convolutional Neural Networks	brain tumor (gliomas) segmentation from MRI images	3C (3*3*2) 22 deep layers	2 average pooling	3F	1 output layer	Activation function: Leaky ReLU (LReLU) / In the last layer: Softmax / Batch normalization / cross entropy as loss function	Stochastic gradient descent (SGD)	BRATS 2015 databases / the performance of whole, core, and enhancing areas evaluated using Dice =0.84, 0.79, 0.75, Positive Predictive Value PPV= 0.88, 0.86, 0.70, and Sensitivity = 0.82, 0.75, 0.86. training duration =140m. the proposed strategy is efficient and time-saving /segmentation the lung nodule depending on the outcomes of this study.
[24]	Deep Neural Networks using the U-net architectur	Lung CT Image Segmentation	2C (3*3)	2P (2*2)	-	-	Rectifier linear units (ReLU)	-	Lung Image Database Consortium image collection (LIDC-IDRI) / accurate segmentation with 0.9502 Dice-Coefficient index was obtained

Table 3: continued

Ref	TECHNIQUE/ methodology	Domain	No. of convolutional layer	No. of Maxpooling/ average pooling/ sample	Filly connected layer	Softmax classifier/ output layer	Type of classification rectifier/ cost function/ activation function	Training using BPA or SGD/ other parameters	Data set/ Result/ Future work
[25]	Deep Multiscale Convolutional Neural Network Model (DMCNN)	Medical Image Segmentation	• Encoder: - 3C layers (1 × 1, 3 × 3, 5 × 5) • U-Net Model: 28C layer end of U-net: 1C layer (1 × 1) • Decoding Part :- 1C layer	1P	-	1 Softmax	Rectifier linear units (ReLU)/ batch normalization (BN)/ sigmoid / loss function	-	dataset is from ADNI (Alzheimer's Disease Neuroimaging Initiative) / evaluation indexes are DSC= 92.54, SEN=91.87, and PPV=92.08, Time=8.5s. the new strategy decreases computation time and improves segmentation accuracy. It also offers a high level of robustness when compared to other segmentation methods. \ future work is to segment different types of images using deep learning methods
[26]	deep learning in segmenting and classifying	Alzheimer's diagnosis in 3D brain MR images	(3*3)	(2*2)	-	3 tissues segmentation ground truth	loss function	-	OASIS, AD-86 and AD-126 datasets / for segmentation in both datasets Dice= 0.96 and accuracies 0.88, and 0.80 for classification, respectively. \ The proposed approach was tested and found to be quite accurate. \ To improve CNN model, some alternatives have been proposed, such as segmenting more brain tissues or lowering loss information in downsampling

III. Conclusion

In image processing, Segmentation is an important pre-processing step in the areas of image analysis. It is a critical and essential component of image recognition system and usually determines the quality of the final result. Different approaches have been introducing, but the accuracy is the main problem for all of these. Therefore, the use of soft computing approaches (SCA) was adopted. SCA involves, fuzzy based approach, genetic algorithm based approach, and neural network based approach. the contribution of this article's is to providing new reviews and summaries for some of the researchers' work on image segmentation based on soft computing approaches (SCA). these approaches were tested on a real-life images. the hopes that it will encourage academics to work on inventing new segmentation methods with more accurate results.

IV. References

[1] B. Baral, S. Gonnade and T. Verma, "Image Segmentation and Various Segmentation Techniques – A Review," *International Journal of Soft Computing and Engineering (IJSCE),* vol. 4, no. 1, pp. 134-139, March 2014.

[2] K. Suresh and P. Srinivasa rao, "Various Image Segmentation Algorithms: A Survey," in *Proceedings of the Second International Conference on SCI,* 2018.

[3] N. M. Zaitoun and M. J. Aqel, "Survey on Image Segmentation Techniques," *International Conference on Communication, Management and Information Technology (ICCMIT)* , vol. 65, p. 797 – 806 , 2015.

[4] S. Saini and K. Arora, "A Study Analysis on the Different Image Segmentation," *International Journal of Information & Computation Technology,* vol. 4, no. 14, pp. 1445-1452, 2014.

[5] M. Kaur and L. Chand, "REVIEW OF IMAGE SEGMENTATION AND ITS TECHNIQUES," *Journal of Emerging Technologies and Innovative Research (JETIR),* vol. 5, no. 7, pp. 974-981, July 2018.

[6] S. S. Chouhan, A. Kaul and U. P. Singh, "Soft computing approaches for image segmentation: a survey," *Multimed Tools Appl 77,* 02 May 2018.

[7] P. Sinha, M. Tuteja and S. Saxena, "Medical image segmentation: hard and soft computing approaches," *SN Applied Sciences*, 07 January 2020.

[8] W. Yong-sheng , "A New Image Threshold Segmentation based on Fuzzy Entropy and Improved Intelligent Optimization Algorithm,"

JOURNAL OF MULTIMEDIA, vol. 9, no. 4, pp. 499-505, APRIL 2014.

[9] U. JAVED, M. M. RIAZ, A. GHAFOOR and T. A. CHEEMA, "SAR Image Segmentation Based on Active Contours With Fuzzy Logic," *IEEE TRANSACTIONS ON AEROSPACE AND ELECTRONIC SYSTEMS*, vol. 25, no. 1, pp. 181-188, February 2016.

[10] S. J. Mohammed and M. Y. Kamil, "Brain Image Segmentation Based on Fuzzy Clustering," *Al-Mustansiriyah Journal of Science,* vol. 28, no. 3, pp. 220-223, 2017.

[11] A. M. Salih and . M. Y. Kamil, "Mammography Images Segmentation Based on Fuzzy Set and Thresholding," *Al-Mustansiriyah Journal of Science,* vol. 29, no. 3, pp. 168-175, 2018.

[12] M. Y. Kamil and A. . M. Salih , "Mammography Images Segmentation via Fuzzy C-mean and K-mean," *International Journal of Intelligent Engineering and Systems,* vol. 12, no. 1, pp. 22-29, 2019.

[13] N. A. Ali, A. El abbassi and B. Cherradi, "The performances of iterative type-2 fuzzy C-mean on GPU for image segmentation," *The Journal of Supercomputing,* 15 June 2021.

[14] C. Tan, Y. Sun, G. Li, B. Tao, S. Xu and F. Zeng, "Image Segmentation Technology Based on Genetic Algorithm," in *ICDSP 2019: Proceedings of the 2019 3rd International Conference on Digital Signal Processing*, Jeju Island, Republic of Korea, 2019.

[15] W. SHANG and Y.-f. CHENG, "An improved OTSU method based on Genetic Algorithm," *Advances in Computer Science Research, 4th International Conference on Machinery, Materials and Information Technology Applications (ICMMITA 2016)*, vol. 71, pp. 1656-1661, 2016.

[16] L. Chen, X. Chen, S. Wang, W. Yang and S. Lu, "Foreign Fiber Image Segmentation Based on Maximum Entropy and Genetic Algorithm," *Journal of Computer and Communications,* vol. 03, no. 11, p. 7 pages, 2015.

[17] S. Abdel-Khalek, A. B. Ishak, O. A. Omer and a. A.-S. F. Obada, "A two-dimensional image segmentation method based on genetic algorithm and entropy," *International Journal for Light and Electron Optics,* p. 16 pages, 2016.

[18] D. Li, Z. Han and a. J. Zhao, "A Novel Level Set Method with Improved

Fuzzy C-Means Based on Genetic Algorithm for Image Segmentation," in *2017 3rd International Conference on Big Data Computing and Communications (BIGCOM)*, Chengdu, China, 2017.

[19] N. H. Rajini, "A Two-Dimensional Image Segmentation Method Based on Hybrid Genetic Algorithm with Particle Swarm Optimization and Entropy," *International Journal of Applied Engineering Research,* vol. 14, no. 9, pp. 2270-2274, 2019.

[20] A. Y. Ayoub, M. A. El-Shorbagy, I. M. El-Desoky and A. A. Mousa, "Cell Blood Image Segmentation Based on Genetic Algorithm," in *Proceedings of the International Conference on Artificial Intelligence and Computer Vision (AICV2020)*, 2020.

[21] N. S. Dagar and P. K. Dahiya, "Edge Detection of Different Images using Soft," *International Journal of Recent Technology and Engineering (IJRTE),* vol. 8, no. 2, pp. 222-226, July 2019.

[22] R. Lang, L. Zhao and K. Jia, "Brain tumor image segmentation based on convolution neural network," in *2016 9th International Congress on Image and Signal Processing, BioMedical Engineering and Informatics (CISP-BMEI)*, Datong, China, 2016.

[23] W. Mengqiao, Y. Jie, C. Yilei and W. Hao, "The Multimodal Brain Tumor Image Segmentation Based On Convolutional Neural Networks," in *2017 2nd IEEE International Conference on Computational Intelligence and Applications (ICCIA)*, 2017.

[24] B. A. SKOURT, A. EL HASSANI and A. MAJDA, "Lung CT Image Segmentation Using Deep Neural Networks," *The First International Conference On Intelligent Computing in Data Sciences,* vol. 127, pp. 109-113, 2018.

[25] L. Teng , H. Li and S. Karim, "DMCNN: A Deep Multiscale Convolutional Neural Network Model for Medical Image Segmentation," *Journal of Healthcare Engineering,* vol. 2019, p. 10 pages, 27 Dec 2019.

[26] A. T. Tran, T. B. Pham and J. Y. K. &. J. M. R. S. Tavares, "Alzheimer's diagnosis using deep learning in segmenting and classifying 3D brain MR images," *International Journal of Neuroscience,* 2020.

دراسة استقصائية لتجزئة الصور بالاعتماد على طرق الحوسبة اللينة

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مستخلص البحث:

تعد تجزئة الصور خطوة أساسية في معالجة الصور، والتي تهدف إلى تسهيل تحليل الصور. يمكن إجراء تجزئة الصورة عن طريق تجميع أو تقسيم بكسلات الصورة إلى مجموعات (مناطق) متطابقة من خلال الاعتماد على بعض الصفات مثل اللون ، أو الملمس ، وما إلى ذلك. وقد تم استخدامها في العديد من المجالات مثل اكتشاف الأشياء، ومهام التعرف، والتصوير الطبي وفي الكثير من المجالات الاخرى. هناك طريقتان أساسيتان لتجزئة الصور وهما الطرق التقليدية وطرق الحوسبة اللينة بالعديد من SCA ، وقد تم اقتراح الكثير من الطرق بناءً على هذين النهجين. تتمتع طرق (SCA) المزايا التي تفوق الطرق التقليدية مثل المرونة والفعالية من حيث التكلفة والأداء العالي. تتضمن طرق والخوارزمية الجينية. تركز (ANN) استخدام المنطق الضبابي والشبكة العصبية الاصطناعية SCA هذه الورقة البحثية على تقديم مراجعة جديدة وحديثة وملخصات لعمل الباحثين على تجزئة الصور المختلفة. سيساعد ذلك الباحثين الجدد في التعرف على هذه الأساليب ثم اختيار SCA بناءً على طرق طريقة معينة منها لتحسينها أو تطويرها لإنتاج طريقة جديدة لتجزئة الصور.

الكلمات المفتاحية: - تجزئة الصورة، الحوسبة اللينة، المنطق الضبابي، الشبكة العصبية، الخوارزمية الجينية.