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A Review of Medical Image Segmentation Algorithms

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Abstract

INTRODUCTION: Image segmentation in medical physics plays a vital role in image analysis to identify the affected tumour. The process of subdividing an image into its constituent parts that are homogeneous in feature is called Image segmentation, and this process concedes to extract some useful information. Numerous image segmentation techniques have been developed, and these techniques conquer different restrictions on conventional medical segmentation techniques. This paper presents a review of medical image segmentation techniques and statistical mechanics based on the novel method named as Lattice Boltzmann method (LBM). The beauty of LBM is to augment the computational speed in the process of medical image segmentation with an accuracy and specificity of more than 95% compared to traditional methods. As there is not much information on LBM in medical physics, it is intended to present a review of the research progress of LBM.
OBJECTIVE: As there is no review paper on the research progress of the LB method, this paper presents a review with an objective to give some thought regarding the different segmentation for medical image and novel LB method to advance interest for future investigation and exploration in medical image segmentation.
METHODS: This paper in attendance a short review of medical image segmentation techniques based on Thresholding, Region-based, Clustering, Edge detection, Model-based and the novel method Lattice Boltzmann method (LBM).
CONCLUSION: In this paper, we outlined various segmentation techniques applied to medical images, emphasize that none of these problem areas has been acceptably settled, and all of the algorithms depicted are available for broad improvement. Since LBM has the benefits of speed and adaptability of modelling to guarantee excellent image processing quality with a reasonable amount of computer resources, we predict that this method will become a new research hotspot in image processing.

Keywords: Segmentation, Medical Physics, Radiation Therapy, Computed Tomography (CT), Magnetic Resonance Imaging (MRI), Radiotherapy treatment planning systems (RTPS), Image processing, Image analysis, Thresholding, Edge detection, Clustering, lattice Boltzmann method (LBM)

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1. Introduction

Image processing techniques have become progressively significant in a wide assortment of applications with sophisticated techniques and instruments. Image segmentation is an exemplary subject in image processing and further hotspot and focal point in image processing techniques. Image segmentation is a technique of partitioning an image into sub constituent parts, remarkably homogenous in feature and this process concede to extract some useful information. Image segmentation accepts a part prominent position in image analysis. Medical images take part in health care as the medical image's quality influences the diagnosis and treatment. Segmentation is significant in medical image analysis and intends to draw out some details from the images. Those images can be utilized for high-level image understanding. Scientifically speaking, segmentation is a hypothetical middle-level vision task performed by neurons between low-level and high-level cortical areas, as schematically shown in figure 1[1]. Segmentation of clinical images intends to find anatomic structures and portray their limits on a computerized source. Especially in Radiotherapy (RT), Imaging is an essential part of the therapy routine since it utilizes to perceive the therapy target and ordinary structures to abstain from irradiation. Hence, Radiotherapy treatment planning systems (RTPS) require anatomical data to be portrayed on CT scans. The treatment target and ordinary structures are physically depicted on CT scans by clinicians. Segmented clinical images are moved to an RTPS for computing radiation dose. Hence, precise segmentation is crucial for the patient treatment result. For the reasons of radiotherapy treatment, segmentation quality incorporates spatial precession and dose computation exactness, which are firmly related [2, 3]. Image segmentation aims to partition the medical image into elemental parts or objects in the medical image with uniform and similar features. One of them is intensity, a colour that relates to anatomical structures, tumours, etc. The degree of segmentation is application dependent, and there is no universal theory of image segmentation. Distinct segmentation methods or algorithms have been proposed in the literature. These techniques conquer different restrictions on conventional medical segmentation techniques. Choice of specific techniques or algorithm over the other depends on the problem's image type and nature. Recent advances in image segmentation techniques have frequently been reviewed [4, 5]. These review articles are driven by classifying the methods utilized for processing pixel data voxel data and their applications in diagnosis, treatment planning and follow up studies; However, methods that have been applied in practice, a shortcoming still exists, an obvious one is a computational speed. This paper in attendance a short review of medical image segmentation techniques based on Thresholding, region-based, Clustering, edge detection, model-based, and the novel method Lattice Boltzmann method (LBM) to augment the computational speed, which is based on the microscopic description of the macroscopic physical process. As there is no review paper on the LB method's research progress, this paper presents a review to give some thought regarding the different segmentation for medical images and novel LB method to advance interest for future investigation and exploration in medical image segmentation.

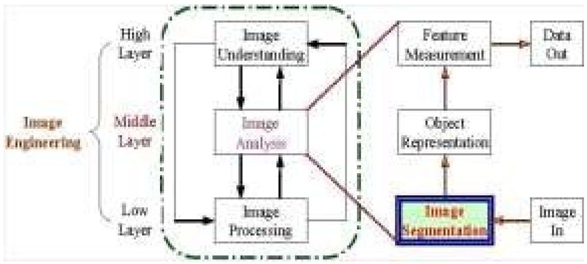

Figure 1. Image Engineering and Image Segmentation [1]

2. Segmentation techniques

Of late, a lot of endeavours have been concentrating on the segmentation process. Distinct segmentation methods or algorithms have been discussed in the literature. These methods conquer different restrictions on conventional medical division techniques. Yet, there isn't so much as one single strategy to be considered a better technique for different kinds of images; those techniques are only suitable for particular images and applications. Image division techniques can be grouped into [6] Thresholding, Region growing & region merging and splitting, Clustering, Edge detection and Model-based methods. All segmentation techniques depend on two essential things of intensity values, discontinuity, and similarity. The discontinuity proceeds towards segment the image based on an instantaneous change in intensity levels in an image or grey levels of an image. In this technique, our interest predominantly focuses on the recognition of isolated points. The second approach is based on the pixels, which are similar in some range as per the preset criteria upon which images are segmented, includes approaches like Thresholding, Region growing, and region splitting and merging.

3. Thresholding approach

Thresholding is the primary method of image segmentation, in which one threshold value is used to change a greyscale image into a binary image. This procedure's important thing is to choose the threshold value (T), pixels with intensity over and above the foreground region's threshold value, and all other pixels in the background region [7]. A few famous strategies utilized in the industry are "The maximum entropy method" [8], Otsu's method (maximum) variance [9]. K-means clustering [9] can also be used in this regard. The presence of noise and obscure boundaries influences Thresholding segmentation and performs well for the images with sharp edges [9]. To invalidate the impact of noise on Thresholding smoothing Image and Thresholding with Edge detection are two regular strategies.

4. Region-based methods

There are three essential techniques for Region-based Segmentation of the Image.

Region growing

At the region growing algorithms beginning of the specific pixel, the region's growth will be dependent on the connectivity with the neighbouring cells depending on similarity criteria corresponding to the greyscale intensity, shape size, or colour defined by the thresholds to expand the growth [10]. The choice of the seed point and the similarity criteria reflects the segmentation results by region growing. Statistical information and prior knowledge assimilated in algorithms to depend on starting seed points and make the algorithm adaptive [11].

Region split and Merge approach

The second method based on the region is the split and merge image segmentation. The said method depends on a quadtree information depiction where splitting of an image takes place into four quadrants with due consideration of the non-uniform feature of the original image segment. If splitting of neighbouring images is discovered as uniform, they are converged by a solitary image made out of the four neighbouring images [11]. The cycle ends when no further merges are conceivable. This technique wipes out the high recurrence artefacts with the seed point selection depend on nearby statistics, utilized for evaluating the breast and cyst mass [11]. These algorithms predominantly depend on the image intensity information to deal with the partial volume effects and control the leakage.

Watershed approach

The other technique that depends on the region is the Watershed method. It views the image as a topographic surface. The idea is that low-intensity pixels are interpreted as valleys of the surface, while high-intensity pixels appear as hills or peaks [12]. The algorithm starts by filling the valleys from local minima if we have seeds that are water sources. Every seed can colour with different coloured water. Those seeds are used to flood such local minima to increase the water in each part. When different water in terms of colour meets, a barrier is built to prevent them from merging from one region to another, the watershed lines [13]. This process of filling with water and barrier construction continues until all peaks are underwater, then the barrier they were found during the process represents the segmentation. In such a way, this algorithm integrates the information of the gradient and grey levels of the image. The gathering of water towards the neighbourhood of local lowest called catchment basins. The pixels in the greyscale images are clone to water beads, and the outcome of the catchment basins are the part of the locale of the image having a like class of pixels. There are two basic algorithm processes to deal with the image using watershed: (a) rainfall and (b) flooding. In the process of rainfall algorithm neighbourhood, lowest is established all over the image. Every neighbourhood lowest is given a distinctive marking, close to neighbourhood lowest is joined with this distinctive marking. A theoretical water drop is kept at each unmarked pixel. The drop makes headway, its negligible sufficiency neighbour until it comes to a marked pixel, where it presumes a marked value. In the process of flooding, single theoretical pixels are kept at each neighbourhood lowest. An ocean of pixels continues to drench the neighbouring area of the pixel located at the neighbourhood lowest. If there is a flood of pixels, the additional pixels are disposed of, and later one is speedier than earlier. Yet, it isn't reasonable for frail boundaries images for the segmentation. Standard watershed methods are vulnerable to excessive segmenting of the images when it contains noise or the objects themselves having a low signal to noise ratio [14]. Excessive segmentation can be minimized by selecting a suitable filtering technique, thereby eliminating the unrelated neighbourhood lowest [15, 16]. The power watershed algorithms unravel the issues in regular watershed algorithms, thereby delivering the ideal outcome [17]. Incorporates the benefits of unsupervised neural network (NN) classification and morphological watershed segmentation to draw out the exact contours of breast tumours from ultrasound images [18]. The new variant stochastic watershed was applied to increase the accuracy of the selected contour [19]. Optimal parameters of the method are tuned utilizing training. Afterwards, they were applied to 17 data sets, and the demonstrated results show that it is a robust tool for automatic liver segmentation compared to the other methods. Extraction of tumour in brain MR images was done using marker-controlled watershed algorithms and distinctive feature combinations [20].

5. Clustering approach

A gathering of homogeneous data into clusters depend on analogy criteria is called Clustering. "K-means clustering (hard clustering)" is the fundamental clustering segmentation algorithms in which the dataset's components belong to only one cluster at a time. Soft clustering approach (FCM) in which the pixel can have a place with greater than one group and the fuzzy community function value is the decisive power to fit in with a pixel in the group, and the value lies in the span of 0 to 1. The pixel position is exceptionally near the centroid, and it very well may be obliged in that class if the community function value is one. The summation of the squared Euclidean separation connecting to each input sample and relating to the cluster centre with the fuzzy community's distances is called the objective function [21]. FCM algorithm is used to partition both grey and colour images; we can set the number of clusters in advance. A difference from the anticipate value may assist us in finding out any shortcomings in the segmentation. In FCM, the objective function can be balanced and stretched out according to the necessities. The convenience of the variability of the objective function makes FCM appropriate for various types of images. The FCM algorithm itself has the facility for the validity measure, thus minimize the computational exertion yields palatable outcomes. Refinement of the FCM algorithms was in practice. The outcome of the customary FCM algorithms is subtle to noise in compensating MR images' intensity heterogeneities. It replaces the Euclidean separation with the kernel induced separation called Kernelized fuzzy C-means (KFCM)[22]. The dimensional penalty was added to the objective function. Presented Fast generalized fuzzy, c-means (FGFCM) clustering algorithm by assimilating the local spatial and grey data in conjunction to suppress the noise and detail preserving for an image [23]. A portion of the upgrades in the regular FCM algorithms was made. It was tested these algorithms in the presence and absence of noise on CT brain images to identify the abnormality region and with a bacteria image to separate the bacteria from the background. They concluded that T2FCM (TYPE-II FUZZY C-MEANS) has efficiently removed the noise with the cost of an increase in the object's size. IFCM (INTUITIONIST FUZZY C-MEANS) was efficient in segmenting the images in contrast to other methods. Proposed "Fuzzy based artificial bee colony (FABC)", where they combined "Artificial bee colony optimization (ABC) "with the "Fuzzy C-Means (FCM)"[24]. They used the Fuzzy community function to search an optimum cluster centre using ABC and tested on synthetic and medical images; the efficiency results were shown in contrast with the other methods. Proposed ARKFCM, a customizable regularized kernel-based algorithm for brain MRI segmentation, upgrades the robustness to preserve image subtleties with the advent of the regularised kernel adaptability [26].

6. Edge detection

It is the most traditional methodology for the detection of irregularity in an image. The separation between two areas having distinct intensity levels or grey level is called Edge. The edges are remarkable in any applications and image enhancement to enhance the details of the image. Derivative operations are used for the Edge's existence in an image, and primarily a convolution function is done on a picture with an appropriate mask [11]. The canny is an efficient edge detector that enhances the Edge; it uses the gradient extent threshold to locate the possible Edge. It stifles them through the system of non-maximal suppression and hysteresis thresholding [27]. Noise in the Image strongly influences edge detections leads to the identified edges comprised of discrete pixels, might be inadequate or irregular; hence before the edge detection, the image has to smooth using the Gaussian operator. The images pre-processing may erstwhile lead to fallacious edge detection and can get rid of multi-resolution Edge detection and Edge tracing techniques [28].

7. Model-based algorithms

Model-based approaches have been set up as probably the best strategies for picture analysis to go with a model. This model contains information about the look forward of the shape and existence of the structure. This technique is sturdier against the artefacts associated with the images than the conventional algorithms.

Markov Random field models

It is a simple stochastic process in which future states' distribution relies only on the current state and not how it arrived in the current state. A random sequence with the Markov property if its present status dictates its distribution is called Markov random fields (MRF), inspired by the Ising model [29]. MRF methods have been broadly utilized to segmentation the images, and the image's revamped since they can protect the edges by parameter approximation [30]. Presented Hidden Markov random field (HMRF) [31], based on a random process created by MRF model whose state of arrangement cannot be watched straightforwardly, which can be seen through an examination. It can be shown mathematically "FM model" is a decadent version of the "HMRF model". By incorporating the HMRF model and an "Expectation-maximization (EM)" algorithm into an "HMRF-EM framework", precise and sturdy segmentation achieved and was exhibited by correlation experiments with the "FM model-based segmentation". Discussed the combination of MRF and SOFM (self-organizing feature map) by incorporating the spatial constraints, which improves the smoothness of partitioning regions [32]. Discussed mass breast segmentation using proclaimed PRF (Pickard random fields), an "Unsupervised MRF model". The PRF model was discovered to be productive compared to the regular MRF in terms of computational complexity [33].

Atlas-based approach

Atlas consists of images, including anatomical subtleties to join earlier data for partitioning and outcome changes depending on the Atlas' particulars. The informational indexes of clinically debilitated subjects and ordinary subjects are used to advance an atlas. Atlas can be a physically marked picture; it possesses a close connection with the picture to be partitioned. The image enrolment takes part in an essential job, and numerous atlases enhance the partition precession [34]. In the image enrolment course, the physically marked Atlas was changed by a mapping strategy frequently named "LABEL PROPAGATION" to precise partitioning the earmark object. The exactness of enrolment is essential since mistakes might happen if there is a topographic distinction between the Atlas and the examination object [35]. Choice of source images for an Atlas development was made by either deciding the population's true mean or collecting the sample closer to the mean. Depending upon several parameters, variable numbers of iterative algorithms could diminish the atlas development's bias effect. On account of numerous atlas partitions, an enormous database is required, and the determination of a proper atlas of the query image is to be done [36]. Labels of Atlas for the earmark depiction was confined by dimensionally changing the fusion weights obtained from neighbourhood evaluation of the enrolment activity [37].

They presented average -shape atlas-based segmentation strategy makeover the preferred outcome over a single atlas-based strategy of cardiac and aortic Segmentation in CT scan images [37]. In this study, authors utilized rib-bone atlases to automatically take out the patient rib bone on conventional chest x-ray (CXR) utilizing the physically alongside the mimicked models from CT and bone images acquired from the dual-energy x-ray machine [38]. During the enrolment, they compute the transformation mapping between the model x-ray and the patient x-ray by the regional similarities between the x-rays, and they apply the result mapping to the rib masks. The average of enrolled models establishes the rib bone likelihood map for the patient-X-ray.

Artificial neural networks

It is a mathematical model of neurons, just like human brain cells inspired by biological neural networks. The node is nothing but a replica of neurons, which may be implemented with specific functional units. These nodes are connected through communication links with synaptic weights. The inputs of these synaptic weights are processed to classify or identify the object with the activation function's help [39]. Training and learning are the two significant features of neural networks. Neural networks are prepared with attributes, perhaps statistical in a feature like mean, standard deviation, kurtosis, skewness, or transfer, depending upon the attributes with the application of Wavelet transform or Curvelet transform. During the training phase, the introductory phase of neural networks is named a speculating phase and progresses until the study state achieved. Moreover, the neural network's training, the more acceptable the outcome related to the examination image. Learning is a customizable activity in which the weights related to the interlinking neurons changed to give appropriate feedback. The Learning process involves neural networks grouped as supervised learning and Unsupervised learning [40]. Neural network algorithms have significant difficulty determining the architecture, network size, type, number of layers, architecture, network size and geographies. The choice of the above said components influence the exhibition of dealing with the problem. Identification of the lungs from the clinical images was described by the "Group Method of Data Handling (GMDH)" [41]. Fuzzy neural networks yield better segmentation result, which was insensitive to noise [42]. Proposed separation measurements utilized by the SVM classifier and also investigated the importance of hyperparameter selection [43]. This method proved that the segmentation accuracy is good apart; it takes less processing time and less memory usage. Worked on segmentation of liver malignancy out of MR images utilizing a combination of "3D fast marching algorithm" and the "Single hidden layer "feed-forward neural network. The results are validated with those physically delineated by a radiologist utilized as ground truth [44]. The time unpredictability was extraordinarily decreased, and precise outcomes were acquired with other semi-automatic segmentation techniques [44]. A deep convolution Neural network (DCNN) was used to identify the brain MR images' glioblastomas [45].

Graph cut approach

The graph cut algorithm's fundamental idea is to borrow tools from the graph theory to partition the image into foreground and background. In graph theory, every pixel will be a node, and the edges are the links that connect those nodes. Connecting links are the probability of that node being foreground or background to connect the source (S) or sink (T) with the weight correlated to the probability, i.e., the Edge's weight. The weight that promotes the pixels that are similar to stay together in the same segment and the different pixels promotes them to become different segments [46]. After constructing the graph, partition that graph by creating a minimal cut with the least effort that partition the foreground and background. With some hard constraints, the cost function represents the boundary and region properties considered as soft constraints for the segmentation. When the hard constraints are changed, the global optimization recomputed as per the new constraints when the cost function is mentioned. In the graph, cut pixels represent the nodes, and edges are the weighed connecting nodes. They compute the global optimal minimum cut to obtain the object & background from the image. They demonstrated this technique with photo, video editing and Medical image processing [46]. They proposed two algorithms to minimize the energy function, which is based on the graph cuts. In the first, the labelling is done among the arbitrary set of pixels so that there is a movement among the labelled pixels so that energy is minimized. The second algorithm requires smoothing. They used three quadratic energy functions first one is with truncated quadratic energy function. The second and third energy functions correspond to the Potts model, and truncated distance as the penalty of smoothness and the results are compared with the different annealing variants. [47]. The graph cut algorithm gives an optimum outcome than the conventional graph cut algorithms with earlier information about the foreground's shape. Multiregional graph cut partitioning is done through kernel mapping of the image data, and the objective function contains original data to assess the deflection of the changed image. The optimization algorithm iterated two consecutive steps: graph cut optimization and fixed point iterations for refreshing the region's parameters. This strategy bears a powerful option in contrast to the complex modelling of the original data while exploiting the computational advantages of graph cut images. This method was quantified and comparatively validated with synthetic, natural, and medical images. Kernel mapping yields good results in the multi-region partition of brain MR images [48].

Lattice Boltzmann method (LBM)

They are powerful techniques with a high degree of accuracy. Lattice Boltzmann method (LBM) is one such simulation technique that depends on the microscopic elucidation of the macroscopic physical process, which has applied widely in kinetic theory to simulate various systems [49]. In LBM, an attempt has been made to close the gap between the macroscopic and microscopic scales by taking the behaviour of a group of particles supposed to behave similarly, rather than a single particle behaviour. Each such collection of particles is given as a distributive function, which represents the collection of particles. In LBM, the solution area is separated into lattices. At every lattice node, the dissemination of particle resides. Some of these particles advance along a specific direction to the adjacent node. The number of directions, linkage relies upon the lattice alignment. The normal phrasing utilized in LBM DnQm, where 'n' speaks the dimension of the problem, 'm' alludes to the speed model, the number of linkages. The crucial element in LBM is the equilibrium distributive function (f^{ew}) with a relaxation time (τ) ascertaining the sort of issue that should have to be tackled. LBM has an alternate tool to the conventional mathematical methods for solving partial differential equations (PDE). LBM is faster, easier, and it has the facility to assimilate large parallel computation and has the advantage of occupying less memory during the simulations as it considers the distribution of particles rather than tagging each particle. The general LBM comprises of two stages as follows: a streaming stage in which particles (or particle densities) moves from one node to another node on a lattice and a collision stage in which particles (or particle densities) are reorganized at each node [50].

The two stages are governed by the LBM evolution equation, where parameter relaxation time(τ) and source term (α) decide the particles' movement. The state of each node at the next moment is only related to the state of its neighbouring nodes because the particles move along the links, and the lattice number and lattice speed govern the links. LBM can be efficiently used in image analysis techniques such as (i)image smoothening [51-53], (ii) image inpainting [54], (iii) image segmentation [55-60]etc. In image processing, each pixel value is considered as particle densities, and changes in pixel value can be considered as a redistribution of particles that are decided by relaxation time (τ) source term (α) in which image information such as gradient and curvature are embedded. LBM in image processing is done, which can be applied easily to complex domains and could be used to serve multiphase and multicomponent flows. Introduced an anisotropic diffusion model dependent on LBM for picture division and showed the adequacy of the calculation in clinical pictures [55], [61-65]. Proposed a novel LBM method using the D2Q19 lattice arrangement model for the Segmentation of MR and clinical images, which is similar to anisotropic diffusion as shown in figure 2 [56], [66-71].

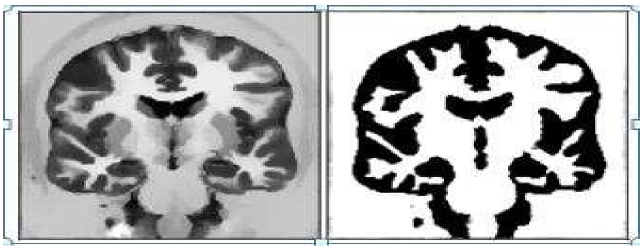

Figure 2. Segmentation of MR image by LBM [56].

(a) MR Image (b) LBM

Utilized LBM to tackle the Level Set Equation (LSE), they proposed a Region-based stop function [71-76]. Unsigned Pressure Force (UPF) in light of regional attribute can adequately and effectively stop the contour at feeble obscured edges [57]. They utilized the parallelizable lattice Boltzmann method (LBM) to solve the level set equation(LSE). This technique is quicker since it is unravelled in histogram space instead of pixel domain [77-81]. The time problem is extensively diminished since the quantity of grey levels is commonly a lot littler than the size of the picture. The strategy is productive, profoundly parallelizable, and quicker than those dependent on the LSM [58]. Edge of object division can be obtained by the Lattice Boltzmann Anisotropic Diffusion Model (LBADM) and indicated their calculation could precisely fathom the convection and diffusion condition [59]. The algorithm incredibly lessens the calculation of division. They proposed a new variation multiphase level set approach to clinical segmentation, calculated multiphase level set conditions and entropy for the LBM model for D2Q9[60]. Demonstrated their method for MR breast images reveals it is more efficient and faster [81-84]. The LBM's merit is a pixel-based algorithm. It deals with the particles, and the pixels are the replica of particles, therefore at any resolution, we can tune the algorithm using various kinds of lattice points. With the increase of lattice points, computational load also will be increasing, and it may be a demerit of the LBM in the view of computation. Since it is particle-based in the microscopic domain, all the macro parameters can be redefined, but since LBM is dealt with, density has to define in a regular structure. In a medical image, getting a regular structure is very difficult; therefore, it may have the LBM's demerit.

8. Conclusion

This paper presents a review to explain the different segmentation for medical images and novel LB method to advance interest for future investigation and exploration in medical image segmentation. Emphasize that none of these problem areas has been acceptably settled, and all of the algorithms depicted are available for broad improvement. Segmentation of medical images is a yet complicated issue in real-time applications like diagnosis and radiotherapy treatment where segmentation algorithm can accurately recognize different tissues encompassing the tumour site and tumour boundaries, henceforth more inventive work is required augment the computational speed. LBM has the benefits of speed and adaptability of modelling to guarantee excellent image processing quality with a reasonable amount of computer resources. The LBM has an exact physical meaning in image processing, the image's pixel value is considered particle densities, and changes in the pixel value can be considered redistribution of particles. It is governed by the relaxation time, which decides the kind of problem needed to be addressed, and the addition of source term is straight forward. The quality of the image segmentation and the computational speed utilizing LBM with high dimensionality and more lattice vectors are expected to comprehend, so we predict that the LB method will become a new research hotspot field Medical image segmentation.

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References

[1] Zhang, Y.J, "An overview of Image and Video Segmentation,".Beijing, China, IGIGlobal;2006.chapter-1, An overview of Image and Video Segmentation in the last 40 years; p.1-16.

[2] Gregory Sharo, Karl D Fritscher, Vladimir Pekar, Marta Peroni, Nadya Shusharina, Harini Veeraraghavan and Jinzhong yang, " Vision 20/20: Perspectives on automated image segmentation for radiotherapy,".Med. Phys.2014; 41(5):p.050902-13.

[3] Najeeb Chowdhury, Robert Toth, Jonathan Chappelow, Sung Kim, Sabin Motwani, Salman Punekar, Haibolin, Stefan Both, Neha Vapliwala, Stephen Hahn and Anant Madabhushi, "Concurrent segmentation of the prostate on MRI and CT via linked statistical shape models for radiotherapy planning,".Med.Phys.2012;39(4):,2214-28 .

[4] Nida M Zaitoun, Musbah J.Aqel," Survey on Image Segmentation Techniques, "Procedia Computer Science .2015;65:p.797 – 806.

[5] Kumar SN, Lenin Fred A, Muthukumar S, Ajay Kumar H and Sebastian Varghese P,".A Voyage on Medical Image segmentation algorithms," Biomedical Research. 2017;Special Issue,Res.p.1-12.

[6] D. L. Pham, C. Xu, and J. L. Prince, "Current methods in medical image segmentation,".Annual Review of Biomedical Engineering. 2000;vol.2:pp.315-337.

[7] W. X. Kang, Q. Q. Yang, R. R. Liang, "The Comparative Research on Image Segmentation Algorithms,".IEEE Conference on ETCS. 2009; pp. 703-707.

[8] R.C.Gonzalez and R.E.Woods," Digital image processing," 2-ed.NewYork: Prentice Hall; 2002.1-813.

[9] R.M Haralick and L.G.Shapiro,"Image Segmentation Techniques,".Computer Vision ,Graphics,and Image processing .1985;Vol-29,Issue 1, p.100-132.

[10] Wu J, Skip P, Michael DN, Marked VK." Texture feature-based automated seeded region growing in abdominal MRI segmentation,".Proc IEEE international conference Biomedical Engineering and Informatics,27-30May 2008,Sanya, China,IEEE,2008;2:263-267.

[11] Thakur A Radhey SA. "A local statistics based region growing segmentation method for ultrasound medical images".World Academy Science Engineering and Technology, Int J Med Health Biomed, Boeing Pharm Eng. 2007;1:564-56.

[12] T.Pavlidis, "Algorithms for Graphics and Image Processing, "Computer science press, Rockville, MD,1982.

[13] Belaid LJ, Walid M. "Image segmentation: a watershed transformation algorithm,".Image Analysis Stereology. 2009;28:93-102.

[14] Hanbury A." Image segmentation by Region-based and watershed algorithms,".Wiley Comp Sci Eng.2009;543-1552.

[15] Biernacki W ." Over segmentation avoidness in watershed based algorithms for color images,".Proc IEEE International Conference Modern Problems Radio Eng Telecommuni Comp Sci,28 Feb. 2004, Lviv-SlavskoUkraine,IEEE, 30 Dec 2004;169-172.

[16] Grau V Mewes AUJ, Alcaniz M, Ron K Simon KW." Improved watershed transform for medical image segmentation using prior information,".IEEE Transactions Medical imaging..2004;23:2606-2614.

[17] Hamid R.Arabnia," Advances in computational biology".Springer Science Business Media, 2010;4-18.

[18] Huang YL, Dar RC." Watershed segmentation for breast tumour in 2D sonography,".Ultrasound MedBiol. 2004;30:625-632.

[19] Lopez MF, Valery N, Jesus A, Alcaniz M Luna L ." Liver segmentation in MRI: A fully automatic method based on stochastic partitions,".Comp Methods Prog Biomed. 2014;114,11-28.

[20] Benson CC, Lajish VL, Kumar R." Brain tumour extraction from MRI brain images using marker-based watershed algorithm,".International Conference Advances Comp Communications Informatics(ICACCI).2015;318-323.

[21] Ahmed MN, Sameh MY, NevinM, AlyAf, Thomas M." A modified fuzzy c-means algorithm for bias field estimation of Segmentation of MRI data,".IEEE Trans Med Imaging. 2002;21:193-199.

[22] Zhang DQ, Song CC ." A novel kernelized fuzzy c-means algorithm with application in medical image segmentation,".Artificial Intel Medicine. 2004;32:37-50.

[23] Cai W SongeanC, Daoqiang Z ." Fast and robust fuzzy c-means clustering algorithms incorporating local information for image segmentation,".PatternRecogn. 2007;40:825-838.

[24] Anjea D, TarunKR." Fuzzy Clustering algorithms for effective medical image segmentation,".Int J Intel Sys Appl.2013;5:55.

[25] AnkitaB, Kalyani M." Fuzzy-based artificial bee colony optimization for grey image segmentation,".Signal and Video Proc.2016;10:1089-1096.

[26] Ahmed E, ChangmiaoW, Fucang J, Jianhuang W, Guanglin L Qingmao H ." segmentation of brain tissues from MRI images using adaptively regularized Fuzzy c-Means Clustering,".Hindawi Publishing Corporation Computational Mathematical Methods Medicine. 2015;1-12.

[27] Nadeem M, Asadullah 88uhnjgbS, AdamuA, Ahafia K Syed BZ." Image segmentation methods and edge detection: an application to knee joint articular cartilage edge detection, ".J Theor Appl Inform Technol. 2015;71.

[28] Lopez-MolinaC, DeBates B, Bustince H, SanzJ, Barreneche E." Multiscale edge detection based on Gaussian smoothing and edge tracking, ".Knowledge-Based Systems. 2013;44:101-111.

[29] Kindermann, Ross; Snell, J. Laurie." Markov Random Fields and their applications,".1-ed. Providance, Rhode island, American Mathematical Society.1980.1-147.

[30] Held K Rota KE, Bernd JK, William MW, Ron K, Muller Gartner HW." Markov random field segmentation of brain MR images,".IEEE Trans Medical Imaging. 1997;16:878-886.

[31] Zhang Y, Brady M, Smith S. "Segmentation of brain MR images through a hidden markov random field model and expectation-maximization algorithm,".IEEE Trans Med Imaging .2001;20.

[32] Li Y, ZheruC ." MR Brain image segmentation based on self -organizing map network,".Int J Inform Technol. 2005;11:45-53.

[33] Segbedji RTJG, YvesG, Hichem M. "Unsupervised malignant mammographic breast mass segmentation algorithm based on Pickard Markov random field,". IEEE Int Conference Image Proc,.2016;156-164.

[34] Hyunjin P, Peyton HB Charles RM," Construction of an abdominal probabilistic atlas and its application in segmentation ".IEEE Trans Med Imaging .2003;22:483-492.

[35] Kang WX, Qing QY, Run PL ." The comparative research on image segmentation algorithms,".Proc First Int workshop Education Technology Computer Science .2009;1:703-707.

[36] CauadraMB, Claudio P, Anton B, Olivier C, Villemure JG, ThiranJP." Atlas-based Segmentation of pathological MR brain images using a model of lesion growth ".IEEE Trans Med Imaging .2004;23:1301-1314.

[37] Ivana I, Marius S, Annenarieke R, Mathias P Max AV, Bram van G "Multi -atlas-based segmentation with local decision fusion application to cardiac and aortic segmentation in CT scans,".IEEE Trans Med Imaging. 2009;28:1000-1011.

[38] Sema C,Stefan J ,Sameer A UlasB,Les RF,Ziyue X,George T." Atlas based rib-bone detection in chest x-rays,".Comp Med Imaging Graphics. 2016;51:32-39.

[39] Dayhoff JE, DeL, James M," Artificial neural networks ".Cancer John Wiley Sons Inc.2001;91:1615-1635.

[40] Egmont P, Michael, Heinz H ."Image processing with neural networks -a review,".Pattrecogn.2002;35:2279-2301.

[41] Tadashi K AbhijitSP, Jack MZ." GMDH type neural networks and their application to the medical image recognition of the lungs".Proc 38th SICE Annual Conference;30-30 July 1999; Morioka, Japan.Japan:IEEE; 1991;1:1181-1186.

[42] WongchomphuP, Narissara E ." Enhance neuro-fuzzy system for classification using dynamic Clustering,".Proc 4th Joint international Conference Information communication Technology Electronics and Electrical Engineering;5-8 March 2014; Chiang Rai, Thailand: IEEE;2014;1-6.

[43] Mohmmad H Hugo L, Phillippe P." Within Brain classification for brain tumour segmentation,". International Journal of Computer Assisted Radiology and Surgery. 2015;11:777-788.

[44] Trong –Ngoc L, Pham The B, HieuTH," Livertumour segmentation from MR images using 3D fast marching algorithm and single hidden layer feed word neural network,".Hindawi Publ Corp Bio Med Research Int. 2016;1-8.

[45] Mohammad H Axel D, David WF, Antoine B Aaron C, YoshuaB, ChrisP, Pierre-MJ, HugoL." Brain tumour segmentation with deep neural networks,".Medical Image Analysis. 2017;35:18-31.

[46] Boykov YY, Jolly MP," Interactive graph cuts for optimal boundary and region segmentation of objects in ND images,".Proc Eighth IEEE International Conference Computer Vision. 2001;1:105-112.

[47] Boykov Y Olga V, Ramin Z. "Fast approximate energy minimization via graph cuts,".IEEE Trans Patt Anal Mac Intel .2001;23:1222-1239.

[48] Ben Salah M, Mitiche A, Ben AyedI." Multiregional image segmentation by parametric kernel graph cuts".IEEE Trans Image Process. 2011;20:545-557.

[49] D.Grunall, S.Chen and K. Eggert." A Lattice Boltzmann model for multiphase fluid flows,".Phys Fluids.1993;5:2557-2562.

[50] A.A. Mohamad "Lattice Boltzmann method: Fundamentals and Engineering Applications with Computer codes," Springer–Verlg London Limited: Springer;2011.1-73.

[51] B Jawerth, P Lin and Sinzinger E "Lattice Boltzmann models for anisotropic diffusion of images,".Journal of Mathematical Imaging and Vision. 1999;11:231-237.

[52] Y Chen, Z.Z.Yan and Y.H. Qian, "An AnistropicDifussion Model for Medical Image smoothing by using the Lattice Boltzmann method,".7th Asian-Pacific Conference on Medical and Biological Engineering. IFMBE Proceeding of APCMBE;22-25 April 2008; Beijing, China.China: Springer; 2008. 255-259.

[53] Wenchuan Zhang, Baochang Shi," Application of Lattice Boltzmann method to Image filtering ", Mathematical Imaging and Vision. 2012;43:135-142.

[54] Y Chen" A lattice-Boltmann method for Image inpainting", 3rd international congress on imge and signal processing (CISP) ;Yantai, China.China:IEEE;2010.vol 3,pp.1222-1225.

[55] Y Chen, Z Yan and Shi J, "Application of Lattice Boltzmann method to image segmentation", 29th Annual international conference of the IEEE engineering in medicine and biology society;22-26 Aug. 2007; Lyon, France.France:IEEE;2007.pp.6561-6564.

[56] Y Chen, Z.Z.Yan and Y.H. Qian," Lattice Boltzmann Method based Medical Image Segmentation.".2009 2nd International Congress on Image and Signal Processing;17-19 Oct .2009; Tianjin, China. China:IEEE;2009.pp.1-5.

[57] S Balla-Arabe, B Wang and X Gao," Level set region-based image segmentation using lattice Boltzmann method,".Seventh International Conference on computational intelligence and security(CIS);3-4 Dec. 2011; Hainan, China. China: IEEE;2011.pp,1159-1163.

[58] S Balla-Arabe, X Gao," Image multi-thresholding by combining the lattice Boltzmann model and a localized level set algorithm,".Neurocomputing.2012; 93:106-114.

[59] Q Wu, Y Chen and G Teng, "Lecture Notes on Electrical Engineering 107 ".Computer, informatics, cybernetics and applications,1-ed.Berlin: Springer.Chapter 61," Lattice Boltzmann anisotropic diffusion model-based image segmentation;p.577-589.

[60] S Balla-Arabe, Wang B and X Gao, "A Multiphase entropy-based level set algorithm for MR breast image segmentation using lattice Boltzmann model".Intelligence science and intelligent data engineering,2013;7751:8-16.

[61] Barot, V., Kapadia, V., & Pandya, S., QoS Enabled IoT Based Low Cost Air Quality Monitoring System with Power Consumption Optimization, Cybernetics and Information Technologies, 2020, 20(2), 122-140. doi: https://doi.org/10.2478/cait-2020-0021.

[62] Sur, A., Sah, R., Pandya, S., Milk storage system for remote areas using solar thermal energy and adsorption cooling, Materials Today, Volume 28, Part 3, 2020, Elsevier, Pages 1764-1770, ISSN 2214-7853, https://doi.org/10.1016/j.matpr.2020.05.170.

[63] H. Ghayvat, Pandya, S., and A. Patel, "Deep Learning Model for Acoustics Signal Based Preventive Healthcare Monitoring and Activity of Daily Living," 2nd International Conference on Data, Engineering and Applications (IDEA), Bhopal, India, 2020, pp. 1-7, doi: 10.1109/IDEA49133.2020.9170666

[64] Pandya, S., Shah, J., Joshi, N., Ghayvat, H., Mukhopadhyay, S.C. and Yap, M.H., 2016, November. A novel hybrid based recommendation system based on clustering and association mining. In Sensing Technology (ICST), 2016 10th International Conference on (pp. 1-6). IEEE.

[65] Pandya, S., W. Patel, H. Ghayvat, "NXTGeUH: Ubiquitous Healthcare System for Vital Signs Monitoring & Falls Detection", IEEE International Conference, Symbiosis International University, December 2018.

[66] Ghayvat, H., Pandya, S., “Wellness Sensor Network for modeling Activity of Daily Livings Proposal and Off-Line Preliminary Analysis” IEEE International Conference, Galgotias University, New Delhi, December 2018.

[67] Mehta, P., Pandya, S., A review on sentiment analysis methodologies, practices and applications, International Journal of Scientific and Technology Research, 2020, 9(2), pp. 601–609

[68] Shah, J., Pandya, S., N. Joshi, K. Kotecha, D. B. Choksi, Load Balancing in Cloud Computing: Methodological Survey on Different Types of Load Balancing Algorithms‖, IEEE International Conference on Trends in Electronis and Informatics, Tamilnadu, India, May 2017.

[69] D.S. Hooda and D.K. Sharma (2008), Generalized R-Norm information Measures-Journal of Appl. Math, Statistics & informatics (JAMSI), Vol. 4 No.2 , 153-168.

[70] Ravi Manne, Snigdha Kantheti, Sneha Kantheti, (2020),"Classification of Skin cancer using deep learning, ConvolutionalNeural Networks - Opportunities and vulnerabilities- A systematic Review", International Journal for Modern Trends in Science and Technology, ISSN: 2455-3778, Vol. 06, Issue 11, pp. 101- 108. https://doi.org/10.46501/IJMTST061118

[71] Dilip Kumar Sharma, “Some Generalized Information Measures: Their characterization and Applications”, Lambert Academic Publishing, Germany, 2010. ISBN: 978-3838386041.

[72] S. Suman Rajest, D.K. Sharma, R. Regin and Bhopendra Singh, “Extracting Related Images from E-commerce Utilizing Supervised Learning”, Innovations in Information and Communication Technology Series, pp. 033-045, 28 February, 2021.

[73] Ganguli S., Kaur G., Sarkar P., Rajest S.S. (2020) An Algorithmic Approach to System Identification in the Delta Domain Using FAdFPA Algorithm. In: Haldorai A., Ramu A., Khan S. (eds) Business Intelligence for Enterprise Internet of Things. EAI/Springer Innovations in Communication and Computing. Springer, Cham

[74] Singla M.K., Gupta J., Nijhawan P., Ganguli S., Rajest S.S. (2020) Development of an Efficient, Cheap, and Flexible IoT-Based Wind Turbine Emulator. In: Haldorai A., Ramu A., Khan S. (eds) Business Intelligence for Enterprise Internet of Things. EAI/Springer Innovations in Communication and Computing. Springer, Cham

[75] Rao, A. N., Vijayapriya, P., Kowsalya, M., & Rajest, S. S. (2020). Computer Tools for Energy Systems. In International Conference on Communication, Computing and Electronics Systems (pp. 475-484). Springer, Singapore.

[76] R. Arulmurugan and H. Anandakumar, “Region-based seed point cell segmentation and detection for biomedical image analysis,” International Journal of Biomedical Engineering and Technology, vol. 27, no. 4, p. 273, 2018.

[77] Dr.S. Suman Rajest Dr. Bhopendra Singh, P. Kavitha, R. Regin, Dr.K. Praghash, S. Sujatha, “Optimized Node Clustering based on Received Signal Strength with Particle Ordered-filter Routing Used in VANET” Webology, Vol.17, No.2, pp. 262-277, 2020.

[78] D Datta, S Mishra, SS Rajest, (2020) “Quantification of tolerance limits of engineering system using uncertainty modeling for sustainable energy” International Journal of Intelligent Networks, Vol.1, 2020, pp.1-8, https://doi.org/10.1016/j.ijin.2020.05.006

[79] Leo Willyanto Santoso, Bhopendra Singh, S. Suman Rajest, R. Regin, Karrar Hameed Kadhim (2021), “A Genetic Programming Approach to Binary Classification Problem” EAI Endorsed Transactions on Energy, Vol.8, no. 31, pp. 1-8. DOI: 10.4108/eai.13-7-2018.165523

[80] Dr. Laxmi Lidiya. S. Suman, Rajest, “Correlative Study and Analysis for Hidden Patterns in Text Analytics Unstructured Data using Supervised and Unsupervised Learning techniques” in International Journal of Cloud Computing, International Journal of Cloud Computing (IJCC), Vol. 9, No. 2/3, 2020.

[81] Haldorai, A. Ramu, and S. Murugan, “Social Aware Cognitive Radio Networks,” Social Network Analytics for Contemporary Business Organizations, pp. 188–202. doi:10.4018/978-1-5225-5097-6.ch010

[82] M. Suganya and H. Anandakumar, “Handover based spectrum allocation in cognitive radio networks,” 2013 International Conference on Green Computing, Communication and Conservation of Energy (ICGCE), Dec. 2013.doi:10.1109/icgce.2013.6823431. doi:10.4018/978-1-5225-5246-8.ch012

[83] A. J. Obaid, "Critical Research on the Novel Progressive, JOKER an Opportunistic Routing Protocol Technology for Enhancing the Network Performance for Multimedia Communications," in Research in Intelligent and Computing in Engineering. Advances in Intelligent Systems and Computing, vol 1254. Springer, Singapore., Springer, Singapore, 2021, pp. 369-378.

[84] S. Sharma and A. J. Obaid, "Mathematical modelling, analysis and design of fuzzy logic controller for the control of ventilation systems using MATLAB fuzzy logic toolbox," Journal of Interdisciplinary Mathematics, vol. 23, no. 4, pp. 843-849, 2020.