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An Improved Algorithm for Segmenting Brain Tumor Images

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Abstract— This paper presents an automated multi-stepped algorithm for detecting the boundary of brain tumor from the MR images. The first step in this process is to remove the noise and other reflections from the given image by pre-processing the image using Median filter. After this, a region of interest is found from these pre-processed images. Finally, Intelligent Water Drops algorithm is applied to find the exact boundary of the brain tumor. After this, the performance of boundary segmentation using IWD is compared with that of Bayesian Approximation method.

Keywords— IWD, Bayesian Approximation (BA), Brain Tumor, MR Image

I. INTRODUCTION

Brain tumor boundary detection is of the utmost importance nowadays in medical line as thousands of cases are being registered daily of this fatal tumor. A brain tumor can be recognized as the tissue having some abnormal mass in which cells keep on multiplying that are hard to control by mechanism of the body. According to the Central Brain Tumor Registry of the United States (CBTRUS), there were 64,530 new cases of primary brain and central nervous system tumors diagnosed by the end of 2011 and they are increasing every day. This necessitates greater effort in the field of brain tumor diagnosis and its exact segmentation from MRI images. For this purpose a number of segmentation techniques are also being used such as Fuzzy C- Mean, Multifractal Texture Estimation, Artificial Bee Colony algorithm, Integrated Bayesian Model etc. But results of these algorithms are not much efficient. Some of them show instability in results by doing over and under segmentation of the exact boundary of the tumor in the image and some results in broken edges.

For this, I have proposed a new approach towards this field i.e. Intelligent Water Drops algorithm. IWD is a swarm based approach that that was introduced in 2007 by H.S. Hosseini and has been used as different problem solving techniques. Due to its tendency to produce many optimal and efficient results, I have inculcated it in detecting the boundary of brain tumor in MRI images.

A number of authors have also proposed many different algorithms for automating this process. Authors [6] have presented an automatic system for segments and labels in glioblastoma-multiforme tumors in magnetic resonance images (MRI's) of the human brain. They have trained this system on three volume data sets acquired from a single MRI system. Further, authors [19] have proposed brain tumor segmentation using Digital Anatomic Atlas and MR Image intensity. They have implemented the fusion of Multi fractal dimension (FD) and Intensity features that significantly improve the brain tumor segmentation and its classification. Next author [7] has used Bayesian formation for incorporating safe model assignments in calculation of affinities which are convention and model free that can be used into multilevel segmentation of brain tumor. Authors have also proposed Artificial Bee Colony to segment the brain tumor from MR images. They have compared this technique with K-means, Fuzzy C-means and genetic algorithms. A fast and robust tool for segmenting solid tumors from images using minimal human intervention to assist and help clinicians and researchers has been proposed by authors [14]. In this paper authors have proposed Cellular Automata (CA) based seeded tumor segmentation method on contrast enhanced T1weighted magnetic resonance (MR) images which makes the standard volume of interest (VOI) and seed selection. Author [22] proposes an automatic technique for analysis of brain tumor magnetic resonance images in his paper. He presents segmentation and detection technique of tumor, edema and healthy tissues from fluid attenuated inversion recovery magnetic resonance images of the brain using composite feature vectors consisting of empirically developed functions of higher order wavelets and statistical parameters. Authors [34] have proposed a new method to segment brain tumor in 3-D MR Images. Its result constitutes the initialization of a segmentation method based on a deformable model, leading to a precise segmentation of the tumors. Nowadays, scientist/ engineers are using nature as a source of inspiration to develop a number of inventions and algorithms. And latest among them is Intelligent Water Drops Algorithm. It is one of the evolutionary algorithms. It mocks some of the processes that occur in nature between the water droplets of river and river bed. Intelligent Water Drops (IWD) is a swarm based technique that was introduced in 2007. It has been used as an efficient problem solving technique. Like the founder of this optimization algorithm, has used it in solving Travelling Salesman Problem [18]. He has concluded that this algorithm is very promising algorithm for solving different problems as it converges fast to the optimum solutions and finds good results. Next author [8] has extended a common framework for graph-based image segmentation that includes the graph cuts, random walker, and shortest path optimization algorithms. He tells that by placing the watershed algorithm in the energy minimization framework opens new possibilities for using unary terms in traditional watershed

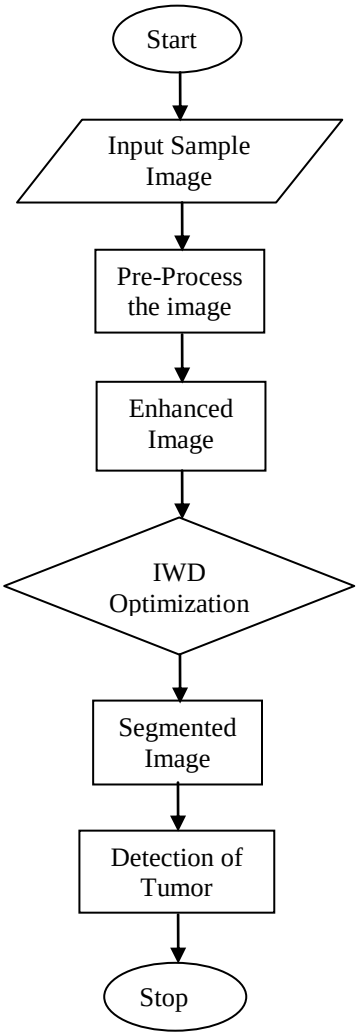
segmentation and using watershed to optimize its use in the applications beyond segmentation. IWD has also been used for solving the air robot path planning problems by the author [9] stating that method is flexible in the dynamic environment and pop up threats are easily incorporated. Further author [16] has used the IWD algorithm and augmented it with a mutation based local search to find optimal values of numerical functions.

II. PROPOSED ALGORITHM

Following are the proposed steps for detecting the boundary of brain tumor using Intelligent Water Drops Algorithm.

1. Preprocessing of the input image to remove noise.
2. Developing the Initial Contour i.e. ROI.
3. Brain tumor boundary segmentation using Intelligent Water Droplet Algorithm.
4. Comparison of results with existing segmentation techniques.

	Algorithm: To apply IWD on sample image
	Begin *Input the brain MR image.* *Pre-processing of the image is done.* *Apply median filter to remove noise from the image.* *Initial contour of the brain tumor is created and corresponding points are plotted.* *IWD algorithm is applied on the region of interest.* *End*



A. Pre-Processing

Pre-processing of the image is the technique that is used commonly to remove noise present in the digital image, normalize the intensity of individual particles in the pictures, and remove reflections and masking portions of the image. It enhances the input data image on which further computations are to be done. Image pre-processing considerably increases the reliability of optical inspection. For this purpose Median filter has been used. It is non linear method to remove noise from an image. It takes median of neighbor pixels and run entry by entry. It preserves edges.

B. Determining Region of Interest (ROI)

Determination of the initial contour is the next step towards detection of exact boundary of the brain tumor in the image. It should be as accurate as possible because performance of the algorithm depends upon it. It is one of the prominent points of this algorithm. In this research, the ROI in the image is constructed as: Firstly, the enhanced MR image is picked for the observation of the expert radiologists. Based on their expertise, a few initial points are chosen having x and y coordinates. This operation is repeated for the required set of sample images. Then the mean of these chosen points is taken and an initial contour is framed on which IWD algorithm can be applied.

C. Boundary detection using IWD

Intelligent Water Drops (IWD) is a swarm based technique that was introduced in 2007. It is one of the latest evolutionary algorithms that mock some of the processes that occur in nature between the water droplets of river and river bed. This algorithm imitates the behavior of natural water drops in the river. This Intelligent Water Drop, IWD for short, has two important properties:

• The soil it carries, denoted by soil (IWD).
• The velocity that it posses, denoted by velocity (IWD).

	Algorithm: IWD process
1.	*Begin*
2.	*From the manually framed boundary, select a seed pixel.*
3.	*Find four neighbor coordinates of it.*
4.	*Find Euclidian distance from seed pixel.*
5.	*The point with least distance is selected as next seed pixel*
6.	*Repeat the process from step 3 to 5 until boundary is formed*
7.	*End*

IWD flows from a source to the destination. It gives the near optimal path to the destination. The optimal path is formed by actions and reactions of the water droplets and riverbeds. When water flows in rivers or lakes, their environment is continuously changing and the path which river follows is never straight. It includes many obstacles, twists and turns. We see that there are a number of paths from a given source to the destination. If the required destination is known then the solution can be calculated by finding the shortest path from source to destination. And in that case, when desired destination is not known, then an optimal path is found based on some given criteria as per the problem.

Algorithm for detecting boundary of brain tumour using IWD

1. Initialization of static parameters
2. Dynamic parameter initialization
   a) Setting values of the parameters as per the given problem
3. Distribution of IWD on the problematic area
4. Solution construction by IWD by updating parameters
5. Local search over each IWD's solution
6. Global parameter updating
7. Total best solution updating
8. Go to step 2 unless termination condition is satisfied.

Attractiveness (i,j) is generated for each point i and its neighbours j; i denotes the pixel intensity of current pixel i (x_1,y_1) and j denotes the pixel intensity of each of its neighbour j (x_2,y_2); N(D) represents the neighbouring distance and is defined as:

$$N(D) = \sum_{j \in NEi} \frac{|D(j-i)|}{Total\ Neighbours} \quad (1)$$

D(j-i) is the Euclidian distance between points i(x_1,y_1) and j(x_2,y_2), calculated as:

$$Dj = \sqrt{(x_2 - x_1)^2 - (y_2 - y_1)^2} \quad (2)$$

III. RESULTS AND COMPARISON

The current section presents the results obtained after implementing the Intelligent Water Drops algorithm for detecting the boundary of Brain tumor from the MR images. Comparison of IWD algorithm is done with that of already existing Bayesian Approximation technique. After this, the results using both the techniques undertaking various parameters are presented in Tables and Graphs. Screenshot results help to identify the difference between both the algorithms that are

chosen to detect the boundary of the brain tumor from sample MR image. Tabular results shows the exact figures of all the parameters chosen to compare the results of both the parameters and graphical results plot these figures in bar graphs for easy comparison in one glance.

A. Screenshot Results

Figure 1: Output image after segmenting the brain tumor by using BA and IWD.

The screenshot results show the detection of the boundary of the brain tumor in the selected images data set by applying both algorithms i.e. Bayesian Approximation and Intelligent Water Drops Algorithm. First image in the screenshot show the boundary created by Bayesian Approximation method. Further to this, boundary around the brain tumor is framed by Intelligent Water Drops algorithm. The last image in this screenshot shows the exact tumor that is visible after the segmentation using IWD. It can be clearly seen that the results we get after applying IWD are much better than the BA. Boundary of the tumor generated by IWD is much more optimal and efficient than the BA.

B. Comparison Table

In this table, the figures of comparison parameters of Intelligent Water Drops algorithm and Bayesian Approximation are shown. Five parameters viz, Pixel Difference, CPU Time, No. of Iterations, Mean Difference and Maximum Difference are taken.

All the values of these parameters are calculated using both the algorithms and are compiled in tabular form for easy interpretation and understanding. Experimental results show that IWD take less CPU time to complete the boundary of brain tumor. Moreover the difference between the pixels selected to form the boundary are less. Other than this, number of iterations taken by IWD to segment the boundary of the tumor is less than BA. Mean Difference and Maximum difference is also less in case of IWD making it more efficient than BA.

TABLE I

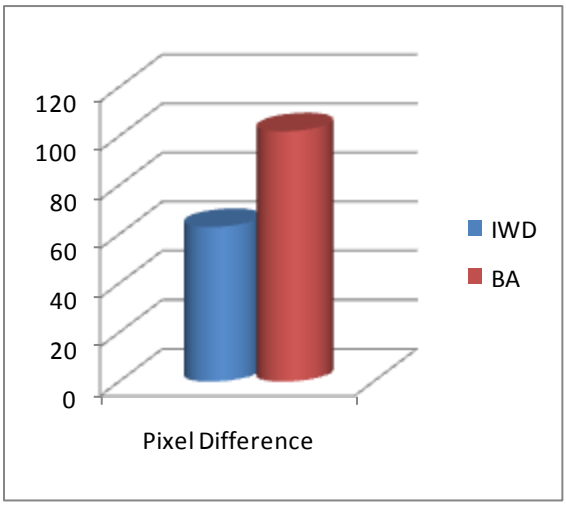
Parameters	**IWD**	**Bayesian Approximation**
Pixel Difference	63	102
CPU Time	0.18857	1.5011
No. of Iterations	160071	299899
Mean Difference (MD)	x = 2.6378e-014	x= 6.0904e-014
	y = 1.0403e-014	y = 4.0602e-014
Maximum Difference (MAXD)	x = 40.2203	x = 50.4
	y = 16.4576	y = 36.2

Comparison table showing resultant values of five parameters using IWD and BA for input image.

C. Comparison Graphs

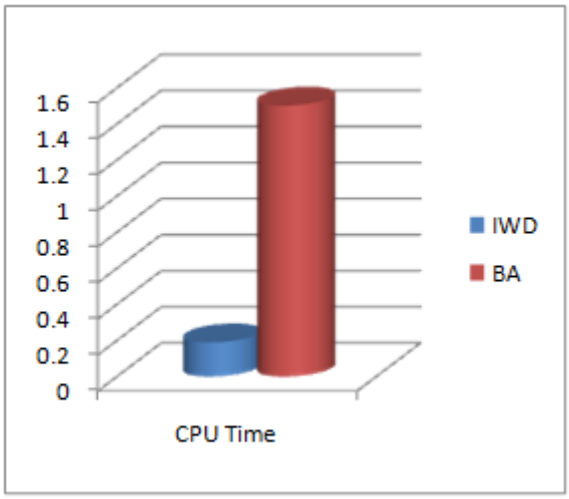
For easy interpretation of the tabular results, the outcomes have been presented in the form of bar graphs as well. Five graphs have benn plotted against five parameters which show the direct comparison of Intelligent Water Drops algorithm with Bayesian Approximation algorithm and from graphical results it is easier to compare the efficiency of IWD over BA.

Following are the five graphs depicting comparative parameters for both the algorithms.



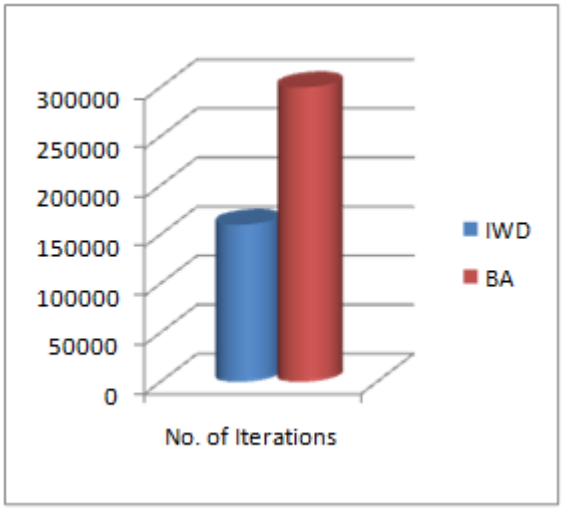
Graph 1: Comparison of IWD and BA (Parameter: Pixel Difference)

This graph shows the difference of pixels in IWD and BA for the formation of boundary of the tumor in the sample image. This parameter computes the total number of pixels taken under consideration by an algorithm to plot the boundary of tumor in the brain MR image. More the number of pixels considered, more is time taken by an algorithm for performing segmentation operation. Therefore, for better optimization this parameter should be less. And results show that IWD take lesser number of pixels to form the boundary of the tumor.



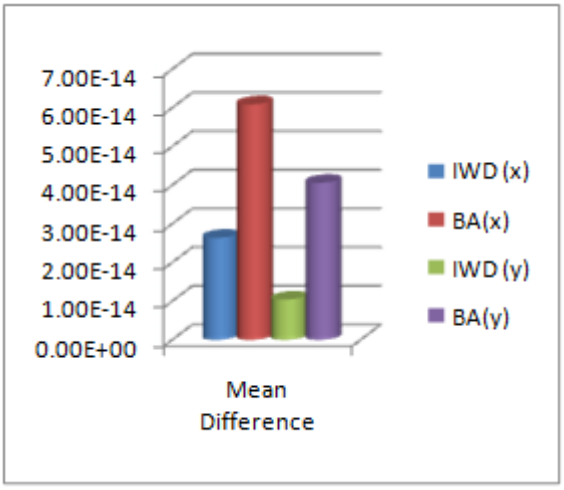
Graph 2: Comparison of IWD and BA (Parameter: CPU Time)

This graph shows the difference between the CPU Time taken to complete the boundary of the tumor in the given sample MR image. More the CPU Time, lesser will be the efficiency of the algorithm. IWD takes lesser CPU Time as compared to BA.



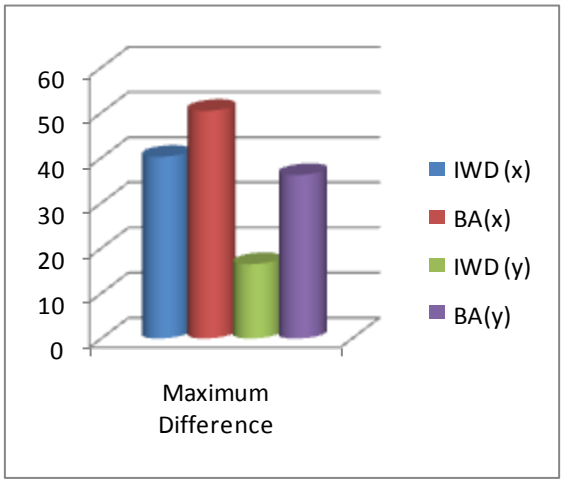
Graph 3: Comparison of IWD and BA (Parameter:No.of Iterations)

The difference between number of iterations taken to create the boundary of the brain tumor in the input image by IWD algorithm and BA algorithm is shown in graph number 3. IWD takes lesser number of iterations than BA proving it more efficient than BA.



Graph 4: Comparison of IWD and BA (Parameter: Mean Difference)

In this graph the comparison of IWD algorithm and BA algorithm is shown on the basis of Mean Difference between the pixels selected for forming the boundary of the brain tumor in the input image. The mean difference between the pixels of the IWD is less for both x and y coordinates.



Graph 5: Comparison of IWD and BA (Parameter: Maximum Difference)

Maximum difference is the distances between the corresponding vertices on the computer generated contour and manually outlined contour taken from the centroid reference point of manual contour. Results show that it is less in case of IWD making it more optimal than BA.

IV. CONCLUSION AND FUTURE SCOPE

The jist of the research work can be concluded as the technique (IWD) used for segmenting brain tumor from MR images is simple to understand and use. It had been used for solving different problems due to its tendency to provide optimal and flexible solutions. Seeing its efficiency, it is one of the newest swarm optimization approaches to be used in segmentation of the medical images. IWD tends to be one of the most efficient approaches for solving complex problems. Before applying IWD to detect the boundary, an image goes through a number of steps like pre-processing of image by applying median filter to remove the noise and formation of a region of interest that is found on which the algorithm has to be applied. After that, the boundary of brain tumor is detected using IWD.

By seeking the comparison with different techniques for segmentation of brain tumor from MR images, IWD comes out be the most optimal one. Practical results show the comparison of IWD with Bayesian Approximation technique based on different parameters like Pixel Difference, Number of Iterations, Mean Difference etc. and all the resultant values are in favor of IWD. IWD takes less time and gives much efficient results when compared to Bayesian Approximation approach.

The work that has been performed in this research opens the way for performing future research in various areas. As of now, human intervention is required to extract the Region of Interest from the images, but in future, this interference can be removed by completely automating the system. Also, this work can be performed on 3D images as well using a larger data set of images.

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