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Research paper

Threshold based brain tumor image segmentation

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Abstract

Image processing is most vital area of research and application in field of medical-imaging. Especially it is a major component in medical science. Starting from radiology to ultrasound (sonography), MRI, etc. in lots of area image is the only source of diagnosis process. Now-a-days, different types of devices are being introduced to capture the internal body parts in medical science to carry the diagnosis process correctly. However, due to various reasons, the captured images need to be tuned digitally to gain the more information. These processes involve noise reduction, segmentations, thresholding etc. . Image segmentation is a process to segment the target area of image to identify the area more prominently. There are different process are evolved to perform the segmentation process, one of which is Image thresholding. Moreover there are different tools are also introduce to perform this step of image thresholding. The recent introduced tool PSO is being used here to segment the MRI scans to identify the brain lesions using image thresholding technique.

Keywords: *Medical Imaging; Tumor; Lesion; Swarm-Intelligence; PSO; Segmentation; Thresholds.*

1. Introduction

Image processing has now become a vital aspect in all of the domain ranging from manufacturing to procurement and starting from environment science to medical science. Image processing is the technique to enhance the raw image sourcing from different equipment's and required for different purposes such as image enhancement, analysis etc.. In current era, we cannot move further without thinking of image and image processing. Any of the marketing strategy relies upon the advanced technologies, among them image processing is a vital one. In the scalability of advanced capturing devices, it also scales the domain of image processing area to a higher level. Images are not only meant of capturing an event or a memory rather it also captures and conveys the major source of information. This needs to read and analyse the data available in the form of images and hence it is known as image analysis. For image analysis we further require pre-processing of data or image which includes image noise reduction, segmentation etc. Image segmentation is one of the most important image processing techniques which are being used in different sectors now-a-days. The segmentation process helps to identify a particular region from the entire image. Most of the time, the entire image space is not required for analysis. So for a particular region or similar region from entire image, image segmentation is important tool. Image segmentation is often used in body scanning devices, ultra sound devices etc. Basic objective of this paper is to highlight the process of identifying brain tumors in MRI images using segmentation. MRI stands for Magnetic Resonance Imaging, is a technique that uses a magnetic field and radio wave to create detailed image of organs and tissues within your body. These images are scrutinized by Doctors or experts to identify the abnormality in it, however it require a lots of human effort and it may be biased for any reason. Therefore, by using segmentation process we can automate the diagnosis process. Image segmentation can be performed by different tools, one of the best tool is Particle Swarm Optimisation (PSO) to perform image segmentation to identify the brain tumor for MRI scans.

2. Threshold based image segmentation

Here one or more than one threshold values are the factors to segment the image. Image is segmented into various regions as per these threshold values. We are paying attention in MRI based gray-scale images. In this type of images, the data range will be [0, L], which means the maximum range will be L depending upon the peak data of image. Here we have taken the 8-bit gray-scale image, so the L will be 255. Image histogram is the main source from which, an appropriate threshold value is identified from maximum intensity.

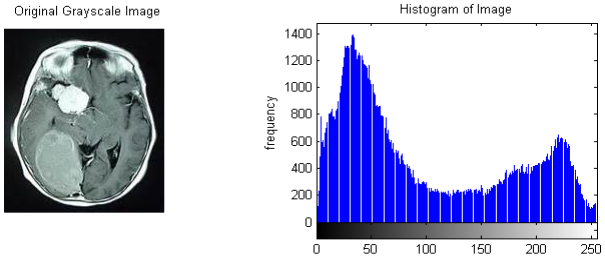


Fig. 1: A) Gray-Scale Image; B) Histogram of Same Image.

2.1. Global Thresholding

Global thresholding is a concept of choosing only threshold value among the gray-levels in the image [1], [2] and by this phenomenon, it produce a binary image according to the identified threshold value. This is also familiar with the name of bi-level image thresholding as it purely segregates the image into two regions i.e. black (0) and white (255). It can be illustrated as equation 1.

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$$\text{Seg (i,j)}=\begin{cases} L, if\ img(i,j) > Threshold \\ 0, if\ img(i,j) \le Threshold \end{cases} \quad (1)$$

Where,

'img' = 2D image or matrix containing various pixel values.

L = maximum gray value (white)

0 = minimum gray value (black)

Semi Thresholding

Semi-thresholding alternately, identified as altered global thresholding, where one specific area takes the value of [0] and the segmented region have its original gray level [3]. Semi-thresholding is clearly illustrated in equation 2.

$$\text{seg (i, j)} = \begin{cases} img(i,j), if\ img(i,j) > Threshold \\ 0, if\ img(i,j) \le Threshold \end{cases} \quad (2)$$

Variable Thresholding

In variable thresholding, the threshold value changes according to the time, there it may depend upon the adjacent pixels, and is known as regional thresholding. In Other case it may be a function of the position of pixel i.e. f (i, j) and identified as adaptive thresholding [1] [2].

Multiple Thresholding

Here, more than one threshold values are involved to segment the image into various regions. In multiple thresholding, if n numbers of threshold values are involved then n+1 number of regions will be extracted from the image.

Particle swarm optimisation

Swarm intelligence is an approach to achieve a common goal by gathering efforts of similar agents. Particles Swarm Optimisation (PSO) is a swarm intelligence method, which impersonates the method of searching food particles by a flock of birds. It optimises the value by a group Optimisation and find the objective value named as "particle". In Particles Swarm Optimisation (PSO), each particle (which represent the actual object in a given problem, as in our case the pixels taken as particles) follows its individual best value (iBest) as well as it follows the universal best value (uBest) among all the particles. All such optimised data are selected by each particle's fitness value obtained from a function named 'Fitness-Function'.

In each iteration, it calculates the individual best (iBest) for each particle comparing with the previous-history of every particle and universal uBest value is populated by comparing the optimum value among the present value of each particle, once iBest and uBest values are calculated, then position and velocities of each particle are updated using equation 3 and 4.[4][5].

$$\text{Vit+i=Vit+Q1 x random () x (Pi - Xit) + Q2 x random () x (Gt - Xit)} \quad (3)$$

$$\text{Xit+i= Xit+ Vit+1} \quad (4)$$

Here, Vit is the velocity of ith. Particle at iteration't', position of ith. Particle at iteration 't' is denoted as Xit. Pi is the individual best (iBest) and Ut is universal best (uBest). Q1 and Q2 are learning factors, (here Q1 = Q2 = 2) and rand ( ) is a random-function [6], [1], [7].

Proposed thresholding method

In this approach, the gray-scale MRI images, containing gray level from [0] to L are used. Hence, the 8-bit unsigned integer gray-scale images are used, therefore the maximum gray level of L is 255 (i.e. 256-1). The Particle Swarm Intelligence methodology is applied to find the optimized threshold value to segment the image into two-shaded region. Here the particle is solution or 'threshold' value and this is a single objective and single level Optimisation problem [9].

Algorithm-1: Image Thresholding using PSO

Step-1. input: brain MRI
Step-2. chose 'n' gray levels pixel as particles
Step-3. Call the PSO-fitness function with 'n' particles(pixel) as input parameter
Step-4. output: The threshold value 'Ti' from PSO
Step-5. Segment the image with the threshold value - 'T':
Segm1 = MAX when imagei(x, y) > Ti ;
Segm2 = MIN or 0 when imagej(x,y) ≤ Ti;

Here Kapur's entropy criterion method [6] is used for fitness-function; it is described here in equation 6. To achieve a near accurate segmentation result we chose a threshold value up to maximum, using the entropy criterion method. Take a 2D gray-scale image having N picture elements (pixels) with gray levels, with a range of 0 to L-1. Let the number of pixels for a particular gray level 'i' is denoted as η(i), then the probabilistic chance of occurrence of gray level 'i' in the image can be found by equation 5 [6].

$$P\ i = \eta\ (i)/N \quad (5)$$

$$F\ (t) = F0+Fi \quad (6)$$

Where

$$F_0 = -\sum_{i=0}^{t-1} \frac{\rho_i}{\omega_0} log_e \frac{\rho_i}{\omega_0}, where\ \ \omega_0 = \sum_{i=0}^{t-1} \rho_i \quad (7)$$

$$F_1 = -\sum_{i=t}^{L-1} \frac{\rho_i}{\omega_1} log_e \frac{\rho_i}{\omega_1}, where\ \ \omega_1 = \sum_{i=t}^{L-1} \rho_i \quad (8)$$

The function defined as equation 6 is a threshold function, therefore a single-objective Particle Swarm Optimisation (PSO), can be applied to the system. It clearly evident from the Algorithm-1.

Experiments

Our proposed method is tested with around 100 different sample brain lesion MRI images with different swarm size and set with different criteria for termination. The system with proposed method is applied to brain-MRI images to identify the bright spots with a swarm size of 10 and for 30 iterations and the result is as shown in Fig.-2 (B).

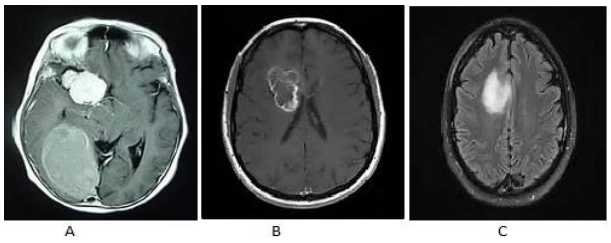


Fig. 2: A) and Brain-MRI; B) Image Thresholding Using PSO; C) Semi Thresholding Using PSO.

We repeat the experiment with the given MRI with 30 iteration having swarm size 10 by applying semi-thresholding, the result which we get is shown in Fig.-2(C). The result of brain-MRI, processed with the usual global thresholding and our proposed method is shown in Fig.-3. From the given images it is clearly visible that, by using the proposed method, we can identify some fine brighter regions from the brain-MRI, which will be add on help for the doctors to diagnose the patient.

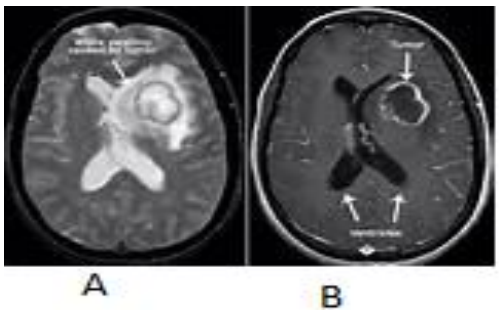


Fig. 3: A) Using Traditional Global Thresholding; B) Using Our Proposed Thresholding Method.

3. Conclusion

Particle Swarm Optimisation is able to give optimised threshold value with in a calculative time period with MR images. The prescribed method helps the radiologist or doctors in the field of medical research for the detection and identification of various abnormal tissue growths like lesion, tumor, calculi etc. in MR images or to detect growth of various abnormal lesion in brain-MRI. In future, continuation of this work will focus on other advanced bio-medical computational methods with swarm intelligence techniques like Ant Colony Optimisation (ACO), Cat Swarm Optimisation (CSO), Fish School Search (FSS), Artificial Bee Colony (ABC) etc. to resolve difficulties in the medical diagnosis. It also make medical diagnosis more economical and reduce the cost effectively.

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