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Implementation of Particle Swarm Optimization Algorithm for Lung Image Segmentation Using Thresholding

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Abstract: Segmentation objects from a digital image is an intricate task in image processing. Image segmentation has a broad range of applications in various domains. Particularly in analysis and diagnosis of medical images, image segmentation plays a vital role. The precision and accuracy are extremely noteworthy in such requests. Even a minute false leads serious problems. Hence it is essential to find an optimum method for medical image segmentation. In this work, we proposed a simple and proficient method to segment lung image. We used image thresholding; a popular method is adopted with particle swarm optimization algorithm as an optimization tool for the segmentation. Particle swarm optimization (PSO) is an optimization search study based on the behaviors of birds flocking for food and other requirements. PSO has no evolution operators such as crossover and mutation. PSO is simple, easy to implement and it has improved convergence rate. Based on the analysis and practical result it is proved that the proposed method has better results than the conventional methods.

Key words: Thresholding · Image segmentation · Particle swarm optimization and Uniformity

INTRODUCTION

A method by which a digital image can be divided into sub-segments is called image segmentation. Its objective is to extract information from an image for further analysis. Image segmentation is particularly used to locate objects and boundaries in images. Pixels with similar characteristics are assigned with uniform labels during segmentation [1]. Based on color, intensity or texture pixels are grouped into one region. Adjacent regions are significantly different concerning the same characteristic [2]. Locating tumor, diagnosis, planning of surgery and treatment decision can be decided only from the decent image segmentation results. Further segmentation is used to locate objects in areas like face recognition, fingerprint recognition, satellite images, traffic control systems, machine vision and agricultural imaging. Plenty of methods are available for image segmentation. Out of that thresholding, grouping the pixels based on intensity is a universal one. It is simple and produces accurate results. The results of segmentation rely on the selection of optimum threshold value. Selection of optimum threshold value can be solved by using particle swarm optimization [3]. Comparative to genetic algorithm PSO has no crossover and mutation. Hence this method becomes simple. Its convergence rate also gets improved than the other optimization algorithms. In this work, we proposed a PSO based thresholding method for segmenting a lung image. The results are verified with four different input images and its output.

Threshold Based Segmentation: Threshold and spatially based methods are two basic types of image segmentation. Objects from the background can be separated using threshold-based algorithm [4]. The threshold based method is most popular widespread practice among researchers since it is more straightforward and efficient one. In this method, the image can be segmented into foreground and background. In the sense, it produces a result in the form of the binary image [4]. In this case for thresholding if we assume a threshold value equals to T, then thresholding process can be considered by equation (1).

$$f(x,y) = \begin{cases} 1, & \text{if } f(x,y) > T \\ 0, & \text{if } f(x,y) \leq T \end{cases} \quad (1)$$

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An optimum threshold value can segregate an image into an object segment and a background segment. It is always a difficult task to determine the optimum threshold value. Earlier researchers did a lot of work in this regard. Sezgin and Sankur have classified the thresholding methods into six groups, including histogram shape-based methods, entropy-based methods, clustering-based methods, spatial-based methods, object attribute based methods and local-based methods [5]. Zhang Jia-shu [6] presents an enhanced threshold segmentation function. Compared to the proposed method the K-means algorithm gets stuck at values which are not optimal [7]. In the research of the threshold method, which is a general approach to image segment, many researchers have put forward some valid threshold selection method. Some researchers [8] significantly saved the computation time under the condition of two thresholds by using genetic algorithms and Ostu and KSW threshold segmentation method together. A detailed overview of various image segmentation and various research issues in this field of study was discussed by Narkhede [9]. The results show that thresholding does not need prior information of the image. And it has less computational complexity. Algorithm for segmenting digital image [3] using thresholding is given below:

- Divide the image into sub-image.
- Choose an optimum threshold for sub image.
- Compare the pixels in that sub-image with threshold and segment the region.
- Consider all sub-images individually and choose corresponding threshold values.
- Stop segmentation when all the sub-images are processed.

Due to computationally inexpensive, fast and simpler to implement the threshold based method is widespread one. Pixels having similar intensity values are grouped to complete the image segmentation. This approach relies on the detection of the best threshold and failing of such threshold may direct to poor segmentation [4]. This paper aims to provide a solution to find the optimum threshold value for thresholding based image segmentation.

Particle Swarm Optimization: Particle swarm optimization is biologically computational search optimization method developed in 1995 by Eberhart & Kenned [5]. Potential solution of a problem is known as a particle. Velocity is constraints that change the flocking of the swarm. In PSO algorithm each has its position and velocity. The position of the particle is influenced by velocity. Let x (t) is the position of the particle at time t. Change in position of the particle is achieved by adding a velocity. Then new position is given by, [10,11]

$$x_i(t) = x_i(t-1) + v_i(t+1) \tag{2}$$

$$v_i(t) = v_i(t-1) + c_1 r_1 \left[p_{best}(t) - x_i(t-1) \right] + c_2 r_2 \left[g_{best}(t) - x_i(t-1) \right] \tag{3}$$

where, c_1 & c_2 – acceleration coefficient – controls maximum step size & r_1, r_2 – random vector

The second part of the equation (3) represents cognition part, the personnel thinking of the particle. The perception part encourages the particle to move towards their best position found so far. The third part is the social part, which corresponds to the teamwork among the particles. The social part drags the particle towards the global best particle found so far. Therefore equation (3) is used to calculate the new particle velocity based on its previous velocity and to the distance of its current position from both its best position and the best position of the entire swarm or its neighborhood. C1 and c_2 are learning rates for individual ability and social influence. The algorithm for a basic particle swarm optimization [12, 13] is given below.

- Initialize the velocity and position of each particle.
- Evaluate fitness value.
- Update the position of each particle based on equation (2).
- The p_{best} and g_{best} are to be updated when conditions are met.
- Repeat 2 to 5 until certain conditions are met or for a predefined number of iterations.

Proposed Method: Preprocessing, foreground segmentation and feature extraction are the three sequential steps implemented in this work. In preprocessing, we used a median filter to eliminate noise from the input image. Median filter has a minimum mean square error and maximum peak signal to noise ratio. Hence it has the best result in isolation of speckle noise in a medical image. Adaptive histogram equalization was used in our work for contrast enhancement. The optimum threshold T can be chosen as a random value between 0

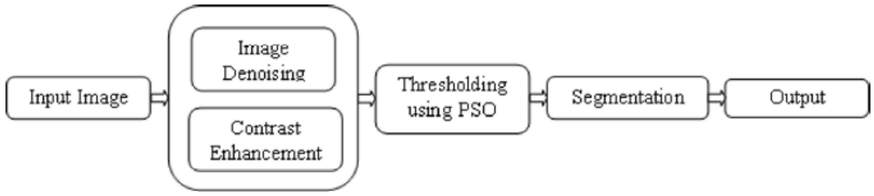

Fig. 1: Block diagram of proposed method

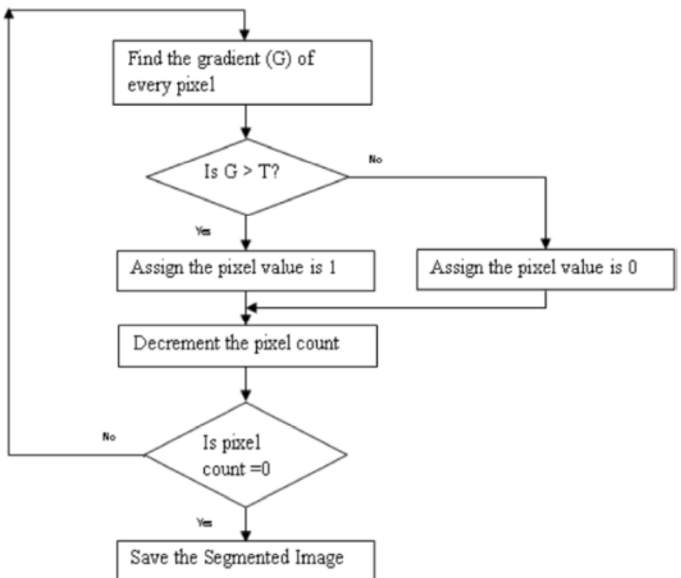

Fig. 2: *Flow chart for segmentation*

and 255. Compute the new velocity and new position based on the fundamental equations of PSO [14-16]. Continue the iteration until it reaches a termination condition. There are lot of discussions on parameters c1 and c2 in earlier researches. In our experiments, they are set as 0.002 which will facilitate convergence towards optimum without deviating more from the region of interest. The block diagram of the proposed method is shown in Figure 1.

The detailed image segmentation method is shown given in Figure 2.

Uniformity Computation: Uniformity in the digital image means unvarying or regular pixels in a segmented image. It is defined as the ratio between the numbers of pixels with correct matching intensity to the total number of pixels in the segmented image. The Uniformity computation measure is given as

$$u = 1 - 2 * c * \frac{\sum_{j=0}^{c} \sum_{j \in R_j} (f_i - \mu_j)^2}{N * (f_{\max} - f_{\min})^2}$$

where,

C – Number of thresholds

R_j – j^{th} segmented region

f_i – Gray level of the pixel i

μ_j – Mean gray level of the pixel in j^{th} region

N – Total number of pixels in the given image

f_{max} – Maximum gray level of the pixels

f_{min} – Minimum gray level of the pixels

RESULTS AND DISCUSSIONS

This section describes the experimental results of the proposed method get better results in image segmentation. Our proposed technique is implemented in MATLAB. The efficiency of proposed scheme is evaluated by comparing the result using hybrid comprehensive learning PSO [12], We have tested our proposed approach using the 8-bit gray scale human lung image. For analysis, we have taken four input image which is shown in Figure 3. In preprocessing we used a median filter for noise removal and the result after filtering is shown in Figure 4. The output after contrast enhancement

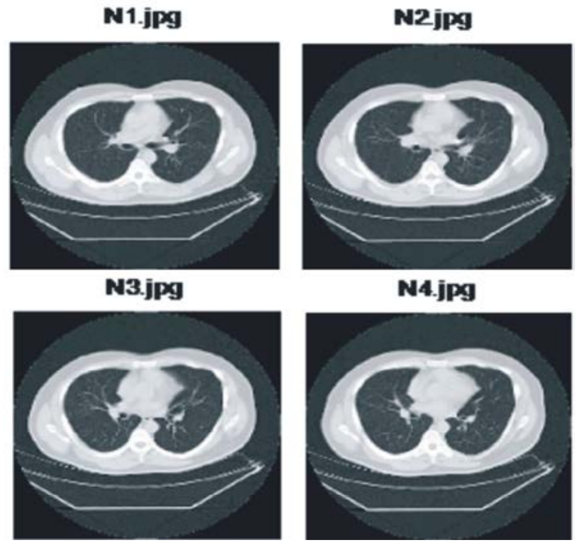

Fig. 3: *Input Images*

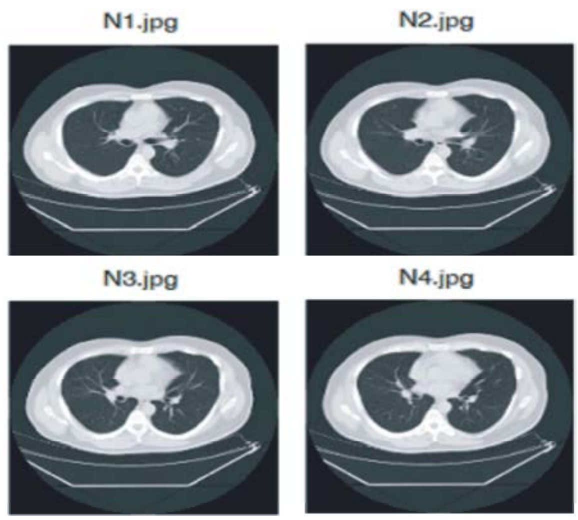

Fig. 4: *Output images Image after filtering*

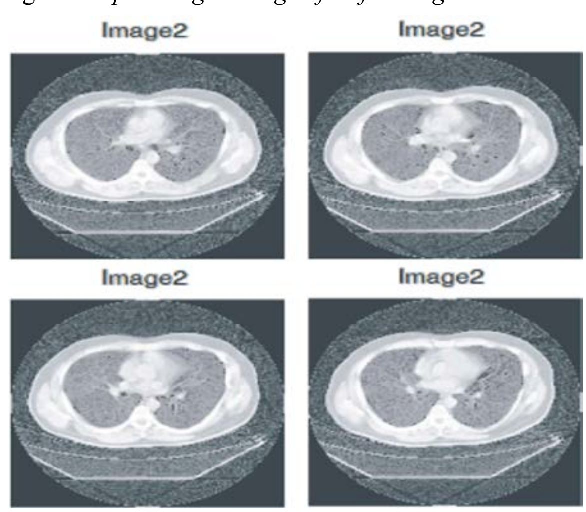

Fig. 5: *Output images after contrast enhancement*

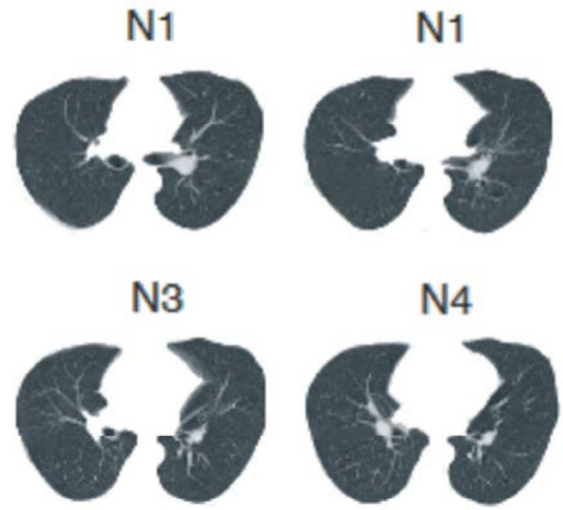

Fig. 6: *Output images after segmentation*

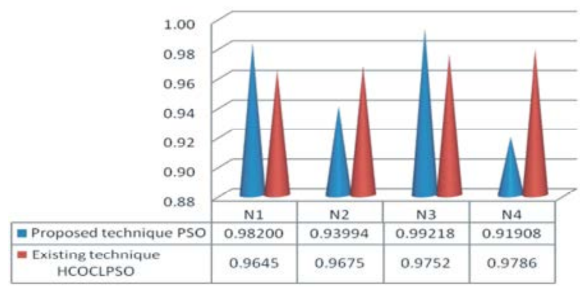

Fig. 7: *Comparison of Uniformity for existing and proposed technique*

is provided in Figure 5. Figure 6. Represents the images after segmentation. Each of the images has a certain part suffered due to disease. The proposed image segmentation technique is applied to all the four input images and the affected part is extracted from the original image which is having high accuracy and uniformity. Figure 7. shows the relative outcome and comparative study concerning uniformity value of the segmented image. The coding for the proposed PSO is experimentally verified and weigh against with the actual result of HCOCLPSO method. In the proposed technique the uniformity value is higher than the previous methods. In images b and d the uniformity is low due to the failure of edge detection.

CONCLUSION

This work explains consistency on uniformity value under maximum entropy with PSO model. The noteworthy purpose of this work is to form an optimization model which is used to find the most optimized solution for the change in parts. The ultimate intention of this paper is to provide the optimized threshold value. The uniformity value provided in this technique is 0.99218. Moreover, the experimental results have shown that the proposed method of image segmentation is more accurate and there has been an improvement in the convergent rate than the hybrid comprehensive learning PSO.

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