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RESEARCH PAPER

OPTIMIZATION OF REAL TIME IMAGE SEGMENTATION USING EFFICIENT THRESHOLDING TECHNIQUE

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A B S T R A C T:
The process of image segmentation is how to divide images into regions with similar properties.–Threshold-based image segmentation is a multidimensional optimization problem that has been highlighted as one of the most significant image pre-processing approaches. This paper proposes an efficient technique for optimizing real time image segmentation. The approach of image thresholding may be regarded an optimization objective, and it will be discovered by using Otsu's technique in conjunction with Particle Swarm Optimization basics (PSO). For real-time validation, the suggested technique was tested on several images in real time using the PSO algorithm. The simulation results showed that, when compared to Otsu's approach, the PSO algorithm gives the most efficient outcomes in real-time applications with an improved execution time.

KEY WORDS: Image Segmentation, Thresholding, Optimization, OTSU Technique, PSO.
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1.INTRODUCTION :

Image segmentation is one of the most challenging processes in image processing. Segmentation is the process of clustering pixels in an image according to certain criteria. The goal is to identify homogenous areas within an image as separate from one another and belonging to different objects (Chin-Wei & Rajeswari, 2010). The most important application fields of image segmentations are medical imaging and robot navigations that have benefited mostly from image processing and analysis.

The study of image segmentation is growing in popularity. With a goal to categorize the numerous objects present in an image based on certain qualities and criteria that vary depending on the intended use. The main criteria employed are gray level uniformity, color, texture, and movement.

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One of the most important techniques in image processing, and particularly in areas such as object similarity, is optimization (Chapagain, 2019). Various optimization algorithms have been applied to enhance the process of image segmentations due to the complexity of the segmentation problem and the great variety of images. The performance of image segmentation for medical images is improved by using optimization techniques (Raju, 2020).

The central position in image processing comes from the truth that, the delineation of objects is usually the first step in other higher level processing tasks, like image interpretation, determination, investigation, visualization, virtual object control, and frequently even registration(Ciesielski & Udupa, 2007). Image segmentation is a technique for extracting useful information from the objects in images (Cohen, 2014).

Segmentation is the clustering of pixels in an image based on a set of criteria. The goal is to detect homogenous regions within an image as distinct from one another and as belonging to various Objects(Chin-Wei & Rajeswari, 2010). Image segmentation is the most challenging and crucial issue in image processing.

In recent years, many scientific publications studied the impact of image segmentation for image processing, segmentation techniques, enhancing and optimization approaches. Several techniques have been proposed and applied to image segmentation for extracting the area of interest of an image. Due to its simplicity and high reliability, thresholding approach is one of the most popular and effective technique of image segmentation for partitioning an image's pixels into separate groups (Cohen, 2014). The pixels selected by the thresholding method are not guaranteed to be contiguous. The main issue with thresholding is that we just evaluate the intensity of the pixels, not any connections between them (Bryan, 2000). Thresholding approach operates by dividing the pixels according to their intensity levels using the image's histogram and a threshold setting. If a pixel's value is less than the threshold, it belongs to the first class; otherwise, it belongs to the second class (Sarkar et al., 2013)(Bhandari et al., 2014). Thresholding techniques are divided into two groups: local and global thresholding techniques (Otsu, 1979)

The primary issue with thresholding approaches is determining the right threshold values. Different metrics depending on the intrinsic information included in the classes verified by the pixels that utilized to accomplish this task. The Otsu approach, for example, computes intraclass variance to get the optimum thresholds (Otsu, 1979)

A wide range of thresholding strategies has been developed over time, and significant research is still ongoing. The Otsu technique, which is widely employed, considerably enhances the image segmentation effect (Chin-Wei & Rajeswari, 2010). (Priyanka Vijay C Patil, 2016) proposed two methods for implementing image segmentation: iteration approach and custom approach. (Goh et al., 2018)proposed a set of conditions to correctly predict the outcome of image thresholding using Otsu technique to guarantee a successful image segmentation. (Lokhande & Pujeri, 2018) proposed a simple PSO algorithm to solve the difficulties concerning image segmentation, which allocates the best value of the objective function of an image randomly. (Houssein et al., 2021) proposed Black Widow Spider Optimization Algorithm which can find the appropriate threshold value for the image. This algorithm makes an attempt to compute the appropriate threshold value without introducing much more complexity.

The objective of this paper is to propose efficient thresholding technique for real time image segmentation based on PSO Algorithm. This algorithm will tend to provide the most efficient results when compared to Otsu's technique with improved time execution.

2. Otsu’s Thresholding Technique

The threshold approach divides a picture into foreground and background using pixel intensities. The Otsu criterion is used to identify the best grayscale image thresholds, which automatically finds the most powerful thresholds for a given number of thresholds. According to the Otsu criteria, any gray-scale image’s histogram can be divided into multiple classes based on the appropriate thresholding levels (Naga et al., 2015). This classification necessitates the selection of a threshold value (th) and the application of the basic rule of :

$$\begin{aligned} &C1 \quad p \quad if \quad 0 \le p \le th \\ &C2 \quad p \quad if \quad 0 \le p \le L-1 \end{aligned} \quad \ldots (1)$$

Where p is one of the m by n pixels in the gray scale image Ig that can be represented by L gray scale levels L = 0, 1, 2, etc. The classes in which the pixel p can be found are C1 and C2, respectively.

OTSU optimize and calculates thresholds by either minimizing within class variance methods or maximizing between class variance will be used as a fitness value function. In this paper maximizing between class for enhancing the segmentation process variance is used as our constrained optimized function (A Mohsen et al., 2012)

$$\sigma_B^2 = \sum_{k=0}^{k-1} w_k - (u_k u_t)^{\,2} \quad (2)$$

Where σ is between class variances
u_k is mean of whole image intensity, and
u_t is mean gray level.

the objective is to maximize between class variance:

$$max(\sigma_B^2) \quad (3)$$

3. Particle Swarm Optimization

Particle swarm optimization is one of SI's best ways for tackling optimization challenges. PSO is a stochastic search method based on the social behavior of flocking birds (Houssein et al., 2021).

PSO's algorithm starts with a set of random particles and then updates generations to look for optima. Each particle is flown through the search space, with its location modified based on its distance from its personal best position as well as the distance from the swarm's best particle. Each particle's performance, i.e., how close it is to the global optimum, is assessed using a fitness function that is dependent on the optimization problem (Nannapaneni, 2018). By minimizing the cross entropy between the original picture and the thresholds, the PSO approach was utilized to identify near-optimal thresholds.

The threshold segmentation technique is treated as an objective optimization issue in the suggested method. It is used to discover the best potential threshold values that will allow us to divide a target image appropriately (Naga et al., 2015) The position and velocity of each particle distinguishes it. The PSO algorithm's working principles are described in the equations below

$$V_{ij^{K+1}} = WV_{ij^k} + c_1 r_1 (pbest_{ij^k} - X_{ij^k} + c_2 r_2 ((gbest_{j^k} - X_{ij^k}) \quad (4)$$

$$X_{ij^{k+1}} = X_{ij^k} + V_{ij^k} \quad (5)$$

Where V_{ij} is the particle velocity and X_{ij} is the position of a specific particle that is updated every iteration k. Each particle has a memory that holds the position where it had the lowest cost ($pbest_{ij^k}$) and the best particle in the population ($gbest_{j^k}$), W representing inertia. c1 and c2 are as-signed weights to the local and global best solutions, respectively. r1 and r2 are random values having a uniform distribution in the range [0,1].

4. The Proposed System Architecture

Otsu approach and PSO algorithm based multi-level thresholding on real time have been applied on a colored image data sets for various environment. Because of the high-level processing and the absence of a powerful Graphics Processing Unit (GPU), the simulation was executed on Google's Colab cloud computing platform. Figure 1 demonstrates the overall proposed system design.

A picture archiving and communication system captures and stores every image from medical equipment. Picture Archiving and Communication System (PACS) is a medical imaging system that provides cost-effective archiving and instant access to images from a variety of sources. The medical application sends the image to the cloud for image analysis and segmentation, with the results saved either in the cloud or in the local hospital data center.

To evaluate the efficiency of the proposed architecture, three groups of images are employed in this study, and each is examined with several categorized images to verify the system's accuracy and robustness. Table 1 illustrates how these groups are classified.

As previously stated, the PSO-based OTSU thresholding dependent on maximizing class in variance is demonstrated in figure 2. For privacy purposes, the algorithm begins by taking a picture from a high-speed Virtual Private Network (VPN) connection. Each image's histogram is created after noise reduction and edge smoothing with the required sophisticated and appropriate filters. The initial values of the PSO algorithm are then applied, and gbest is calculated using the initial values. Finally, the system operated until the best threshold values were identified, and the segmented image will be stored and evaluated for further processing such as decision-making for a specific medical action.

Table 1. Datasets

Group No.	Group Name	Dataset
G1	CT-SCAN (Chest Analysis)	NIH American Research Center
G2	MRI (Brain Tumor)	The Cancer Imaging Archive
G3	CCTV (Security Reason)	GitHub Repository

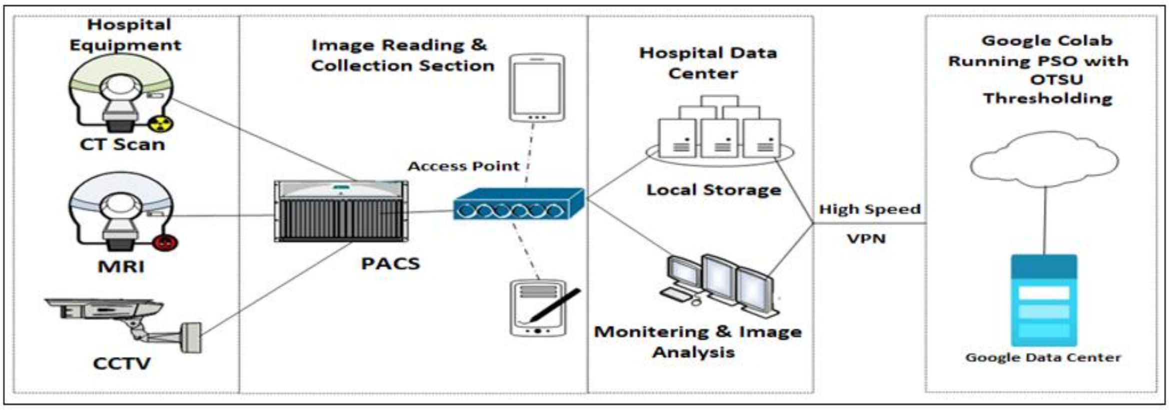


Fig.1. The Proposed System Architecture

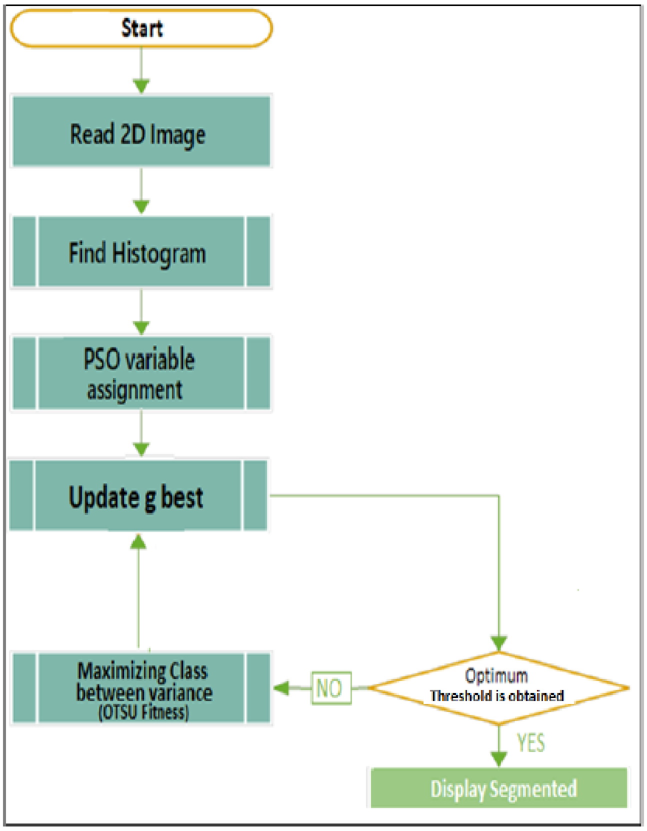


Fig. 2. Flowchart of PSO-based OTSU

5. Results and Discussion

The images will be read in real time and fetched into the cloud, for simplicity one image of each group of thedatasets are under the test. Each image and their histograms and segmented images are shown in the figures 3, 4, and 5 using Otsu base PSO algorithm.

Table 2 shows the thresholding values of OTSU technique, applied PSO based OTSU method, and cloud-based CPU time. The percentage decrease of each image is shown in figure 6.

Table 2 Otsu and PSO based OTSU thresholding

Image. Group	No. Th	OTSU Thresholding	Ex. Time (ms)	PSO-OTSU Method	Ex. Time (ms)
G1	2	118,206	0.35	118.5,217	0.27
	3	74,153,220	1.34	74,154,219	0.6
	4	62,127,180,128	2.2	63,128,180,129	0.45
	10	27,52,74,96,122,148,176, 201,223,244	4.9	27,52,76,97,124,151,177, 202,223,249	0.5
G2	2	28,89	0.29	29,89	0.19
	3	23,59,102	0.42	25,58,104	0.22
	4	35,74,139,231	2.9	37,75,141,232	1.1
	10	21, 46,61,81, 106, 132,154, 215, 232, 253	9.56	22,47,62,82,107,132,155, 215,233,253	2.23
G3	2	90,76	0.65	91,77	0.45
	3	66,119,188	1.32	66,1120,188	0.59
	4	57,101,150,205	4.25	57,101,150,208	1.05
	10	26,50,71,90,110,131,153, 170,212,237	15.16	24,52,72,90,112,132,154, 171,214,238	2.31

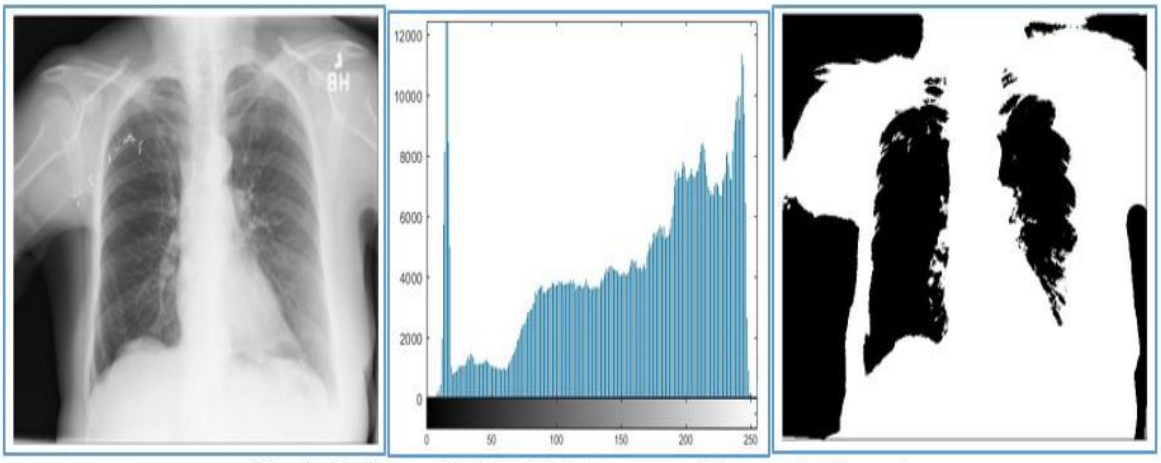


Fig. 3. G1 Image (Original, Histogram and Segmented Image)

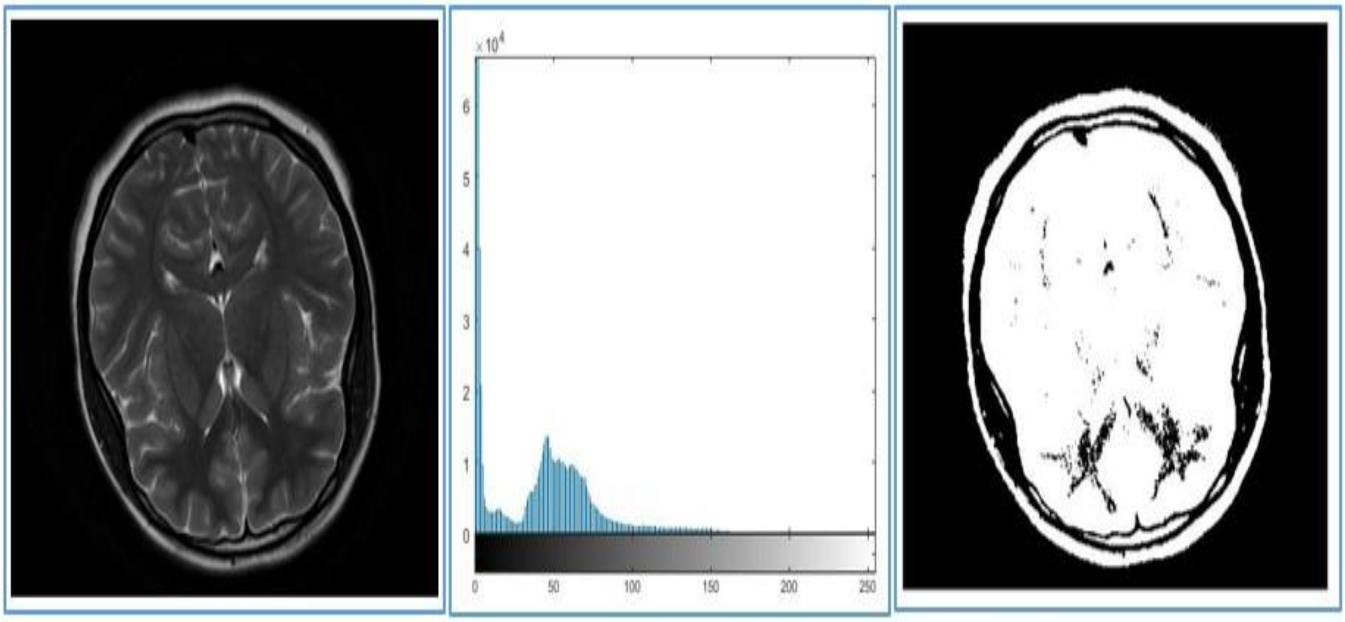


Fig. 4. G2 Image (Original, Histogram and Segmented Image)

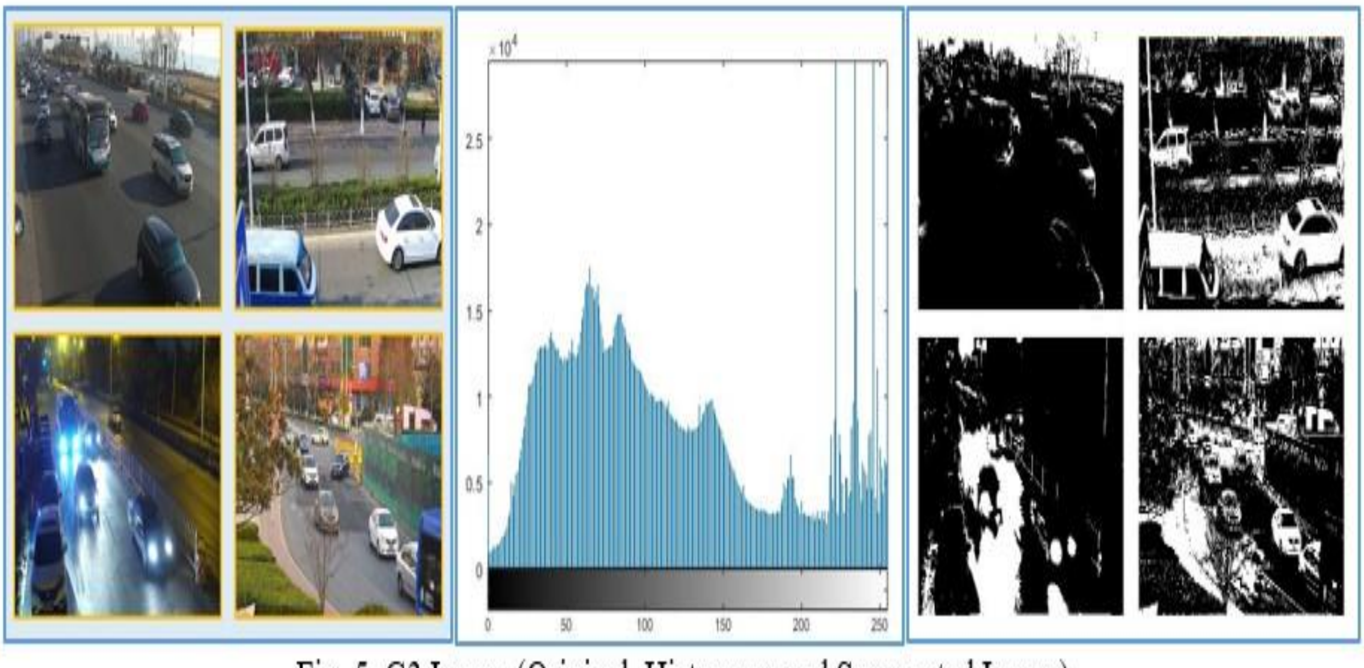
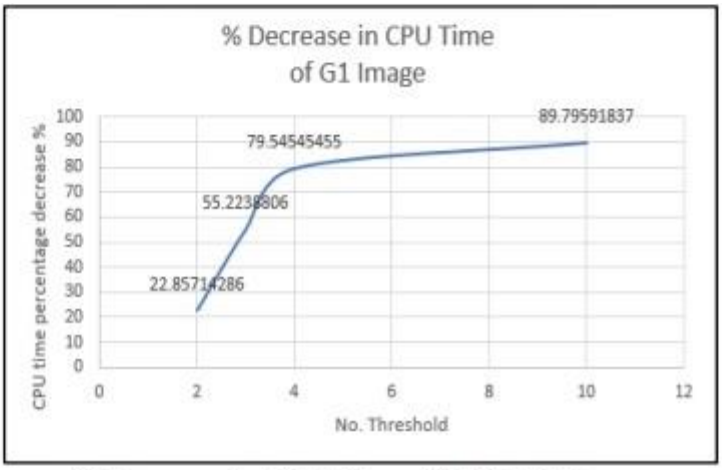
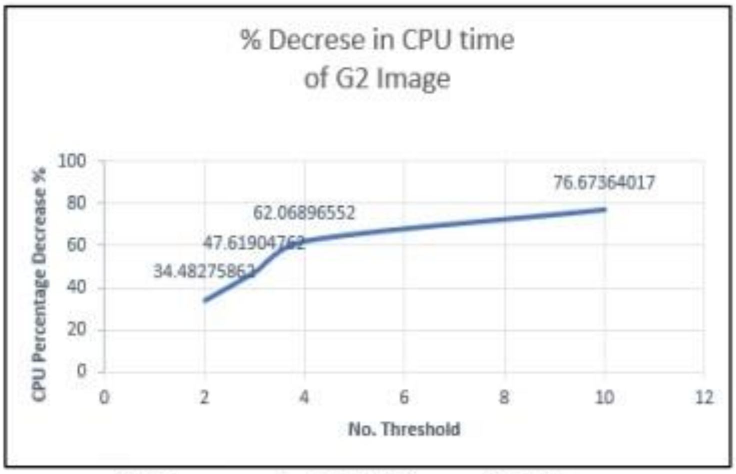


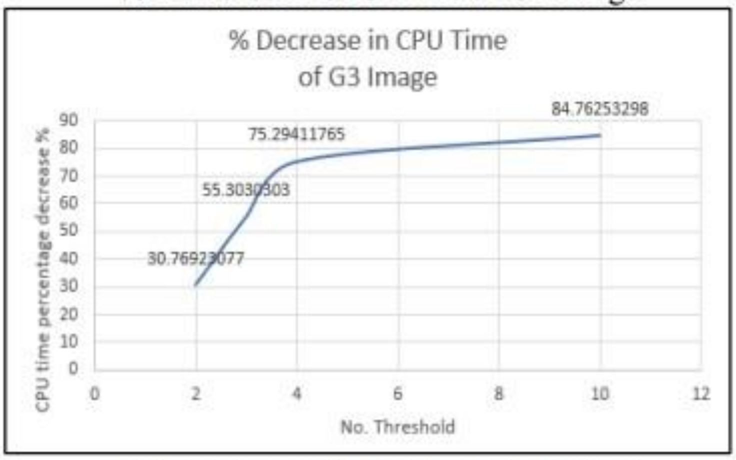
Fig. 5. G3 Image (Original, Histogram and Segmented Image)



% Decrease in CPU Time CT-SCAN Image



% Decrease in CPU Time of G2 Image



% Decrease in CPU Time of G3 Image

Fig. 6. % Decrease in CPU Time of G1, G2 and G3 Images

6. Conclusions

The process of image segmentation is how to divide images into regions with similar properties. The approach of image thresholding may be regarded an optimization objective, and it will be discovered by using Otsu's technique in conjunction with Particle Swarm Optimization basics (PSO). Image segmentation is a multidimensional optimization problem that has been highlighted as one of the most significant image pre-processing approaches. It is crucial in many areas and applications, Otsu based threshold approach image segmentation has been widely used to solve the problem of image segmentation dynamics and the process of CPU execution time enhancement.

This paper proposed an efficient and innovative technique for optimizing real time image segmentation. Compared to Otsu's approach, the PSO algorithm gives the most efficient out-comes in real-time applications with an improved execution time.

The simulations are applied on a database of a set of digital images in three different groups. The findings in this paper revealed that, the enhancement of the total CPU execution time within the range of (22.85%-89.79%) for GROUP1, (34.48%-76.67) for GROUP2, and of (30.76%-84.76%) for GROUP3. The obtained results and evaluations confirmed the theoretical principles and the effectiveness of the presented idea and robustness of the proposed segmentation architecture.

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