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An Improved Particle Swarm Optimization Method for Color Image Segmentation

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Abstract— Color image segmentation can be treated as a process of dividing a color image into some constituent regions. This paper presents color image segmentation method using an Improved Particle Swarm Optimization (IPSO). The RGB color image taken as an input image and remove the noise using Gaussian filter. The obtained preprocessed image the components are separated and find the object regions separately. All the ungrouped pixels would be detected and put in the nearest region. The main purpose of proposed IPSO method is used to find the best values of thresholds, particles and position that can give us an appropriate partition for a target image. This method tries to treat pixels as particles and provide them search space and motivated with IPSO. It findings to better optimized region and produces more accurate segmentation results for color images. The proposed method is tested on different single and group of color images are taken as the input image and the experimental results demonstrate its effectiveness.

Keywords— IPSO, Gaussian Filter, Color Component

I. Introduction

Image segmentation is considered as an important basic operation for more meaningful and easier to analyze interpretation of an image acquired. It is very useful in separating objects from background or discriminating objects from objects that have different gray levels. Color image segmentation is considered one of the most popular areas in the field of image related research works and it plays important roles in many practical applications among which object detection. The goal of color image segmentation is to represent an image in a way that is easier to understand. In image component classification and segmentation is also motivated by several important factors. The main advantage of segmentation of that object detection can be performed independently of the size and position of the object in the image.

Particle Swarm Optimization (PSO) is one of the emerging image segmentation technique inspired from the nature. It has been widely used as an optimization tool in areas including telecommunications, computer graphics, medical science, signal processing, data mining, robotics, neural networks, etc. Particle swarm optimization belongs to the class of swarm intelligence methods that are used to resolve optimization problems [1]. The segmentation algorithm was based on pushing hypothetical objects by the robot, which gave a plenty data on tell the object apart the background. It is still difficult and challenging to do this for fully automatic color image segmentation. The approaches take too much computational time to implement in real time and may not be deadly available conventionally, in order to detect the color and the position of the particular objects must tune six thresholds to limit the HSV color space manually for color image segmentation. It takes large time to reach the best eye to hand cooperation system in the setup time. To obtain a target image and figure out the color information distribution for color images.

Recently, Swarm Intelligence (SI) has been applied in several fields including optimization problems. The PSO algorithm is easy to implement and has been effectively applied to solve a wide range of optimization problems in image processing fields including image segmentation [2]. Image segmentation is a low-level image processing task targeting at partitioning an image into homogeneous regions [3]. The result of image segmentation is a set of regions that cover the complete image or set of contours extracted from the image. All of the pixels in a region are similar with respect to some features such as color, intensity, or texture. Image segmentation methods have been classified into numerous categories of which region and thersholding based segmentation.

Thresholding based segmentation method is one of the most popular and effective method used in image segmentation.

Over the years a wide range of thresholding techniques has been developed and significant research continues nowadays. The thresholding is to determine a threshold for bi-level thresholding or several thresholds for multilevel thresholding giving a suitable classification for pixels in an image. Thresholding based methods work on the assumption that the foreground and background are of varying intensities [5]. When the gray levels are plotted through a histogram, the resulting histogram provides separate peaks for the object from the background. A carefully chosen threshold from the histogram separates the object from the background. But, it does not provide good segmentation due to its simplicity. Boundary based method basically uses object boundaries such as edges, contours for object extraction from background. Region based approaches relies on the region similarity or region dissimilarity for segmentation. The hybrid method combines two or more approaches for better segmentation performance.

This paper presents a thresholding and region based image segmentation method using improved particle swarm optimization. This algorithm will try to find the near-optimal threshold values that can give near optimal segmentation for a target image according to a fitness function. This paper is organized as follows. Section 2 gives an overview of the PSO method. Section 3 gives a proposed methodology and section 4 presents experimental results and discussion and finally conclusions are stated in Section 5.

II. RELATED WORK

The two dimensional histogram analysis and entropy maximization threshold approach is used to segment fray scale images. In PSO algorithm try to solve the 2-d entropy problem. The tumor is localized and detects the edge of the tumor images. An iterative scheme is used to obtain initial values of these candidate multilevel thresholds using PSO variant method. It makes a new contribution in adapting social and momentum components for PSO method. It is not simple to determine exact locations in a multimodal histogram in an image [6]. The PSO based method to search cluster center in the number of naturally occurring regions in the data and their application in image segmentation. Image segmentation problems have is tried to minimize the features and minimize the overall deviation. Dynamic clustering algorithm to find the optimum number of clusters in a data set with minimum number of user interference.

In color image segmentation Otsu method were applied for each of the R, G and B images are separately to determine the suitable automatic threshold for each channel. After that the new channels are integrated for a second time to formulate a new color image. The resulted image suffers from some kind of falsification [8]. The most of the color image segmentation methods are challenged the problem of multi- dimensionality. The lab color space conversion has been used in this method to reduce the one dimension and geometrically it convert in the array hereafter the additional one dimension has been reduced [9]. A saliency directed color image segmentation approach using simple modified particle swarm optimization is proposed, in which both low level features and high level image semantics extracted from each color image are employed. A saliency directed color image segmentation approach using modified particle swarm optimization is proposed, in which a visual attention model is employed in an efficient and accurate manner.

The Karhunen-Loeve transform is help to reduce the redundant component, thus selecting the most significant part of the color images. A multi threshold Otsu method is selecting the best thresholds from image histogram. The karhunen-loeve based multilevel Otsu together with Sobel edge detection and k-means clustering method to extend the traditional gray level Otsu method try to achieve the color image segmentation. The latest watershed segmentation process is actually found in the object feature extraction process. The object features are usually taken from the new watershed segmentation method in which segmented objects are usually grouped with the PSO-SVM method. Displayed in an image collection with remote sensing features and even then the relevance of the semantic attributes is certainly not nicely displayed in the approach [10]. Background elimination is treated as an optimization problem and is solved by using principles of PSO. The proposed algorithm is a thresholding method used to eliminate background from an image assuming that the image to be threshold contains two classes of pixels or bi-model histogram [12].

Color is one of the properties which add information to the images and segment the image based on color space and Otsu method. To realize an image, one needs to isolate the objects and have to find relation among them. The separation of objects is denoted as image segmentation. It has been found that segment regions and there is no much overlapping and gives us the larger object as the result [14]. Salient object detection (SOD) is the task of localization and segmenting the most conspicuous foreground objects form the scene. Computer vision mainly helps to find the objects that efficiently represent a scene and thus solve complex vision problems such as scene understanding [18].

III. METHODOLOGY

In the proposed method of Improved Particle Swarm Optimization (IPSO) pixels are treated as particles where each particle owns a feature vector and distances between these feature vectors are the main criterion to form regions. After forming the initial regions the rest of the particles and also the representative of the existing regions will enter a moving space in search if similar particles or regions. In this regard they would be given a position and velocity for motion purposes. While moving particles would be able to see homogeneous particles and they form new regions. In the last step, ungrouped pixels would be detected and would be put in the nearest region. The proposed method of IPSO block diagram is shown Fig.1.

A. Preprocessing

The initial step is involved in information gathering is to pre-process the information suitable for the required process. Pre-processing aims to reduce the effect of noise and to blur the false contours that may be present in an image. A Gaussian filter has been used this work for this purpose to reduce the high frequency noise component of the image. Gaussian filter focuses on the central pixel by considering all the neighbouring pixels depending on the size of the filter.

B. Extraction of Color Components

The input color image can be represented by three color components which is a resultant of three separate color filters. The input image is decomposed into R-image, G-image and B-image providing individual details of the components. The Gaussian blur image begins with separation of individual R, G and B color components of the RGB image. Each color components is individually processed for extraction of object regions. The component classification image extracted from each pixel it will form a feature vector and act as particles in our method. The feature vector is composed of seven elements in which the first two elements are the coordinates of the pixel in the image and would be considered spatial information. The next three features are R, G and B color components and the last two features are the variance and mean of 3 x 3 matrix around the pixel which would be considered as texture information. The feature vector is described as follows:

$$Vi = (v_i^1, v_i^2, v_i^3, v_i^4, v_i^5, v_i^6, v_i^7) = (x_i, y_i, r_i, g_i, b_i, h_i, m_i,) \quad \text{for } i=1, 2, \ldots, n \qquad (1)$$

Where,
'n' is the total number of pixel in an image
'x_i' and 'y_i' are the coordinates of each pixel in the image plane
'r_i', 'g_i' and 'b_i' are color component extracted from the RGB input image
'h_i' and 'm_i' are variance and mean value of the nine pixel in 3 x 3 matrix centered by the considered pixel

Spatial information has been put in the feature vector intentionally because it helps distinct region forming. The distance between each particle and all other particles is calculated according to Euclidean distance. To form the initial regions in the image a simple thresholding approach is applied to an iterative procedure. After collecting all particles whose distances to the considered particle is under the specified threshold, φ, the minimum overall would be chosen and these particles are merged and new particle is created. Finally, for accurate location of object region the intersections of all the individual object regions are considered. The object region obtained by intersection is replaced by the original RGB components separating the object from the background.

C. Extraction of Regions of R, G, B

Region geometrically located between object and background is composed of intermediate gray values between object and background. For extraction of region a number of descriptors are available. The local variance as region described as the area having higher variance generally contains edges, whereas the homogeneous regions have less variation. For m x m local neighborhood centered at a pixel, the local variance can be calculated as

$$\mathrm{LV}(i,j) = \sigma^2 = \frac{1}{m^2-1}\sum_{x=1}^{m}\sum_{y=1}^{m}(f(x,y) - \bar{f}^2) \qquad (2)$$

Where, (x, y) denote a local coordinate in a given neighbourhood of the sub image f and $\bar{f}$ is a gray level mean of that neighbourhood. The above process is applied throughout the image by sliding the window from left to right and top to bottom to achieve the following variance matrix.

$$LV = \begin{matrix} LV(1,1) & LV(1,2) & \cdots & LV(1,N) \\ LV(2,1) & LV(2,2) & \cdots & LV(2,N) \\ \cdots & \cdots & \cdots & \cdots \\ LV(M,1) & LV(M.2) & \cdots & LV(M,N) \end{matrix} \qquad (3)$$

Where M and N are height and width of an image. The local variance is compared with a threshold to find the region, according to the equation,

$$\Omega_R(i,j) = \begin{cases} 255 & if\ LV(i,j) \geq T_g \\ 0 & otherwise \end{cases} \qquad (4)$$

Where Ω_R is the region of an image and T_g is the global threshold which is basically the gray level mean of the original image. The global threshold can be determined as

$$T_g = \frac{1}{M\ X\ N}\sum_{k=1}^{m}\sum_{l=1}^{m} F(k,l) \qquad (5)$$

Where, F is the original image to be segmented by size. F (k, l) is the gray level value at coordinate (k, l).

The obtained particles have the ability to move and search for other homogeneous particles where the representative feature vector takes part as the particle. For having the particles in the motion give them position and velocity and these parameters will be updated during this procedure using equation

$$\begin{cases} v_i^{k+1} = \frac{1}{M} * (W * v_i^k) + rand \\ x_i^{k+1} = x_i^k + v_i^{k+1} \end{cases} \qquad (6)$$

Where,

'v_i' and 'x_i' are velocity and position
M is the mass related to the region
W is a factor
rand is a random number
k indicates the iteration number

Then W is introduced as a descending parameter which is initially set to a higher value, $w_{initial} = 1$ and finally it becomes w_{final} = 0.5 Therefore a linear relation is defined per iteration to update W according to:

$$W = (w_{initial} - w_{final}) X \frac{k_{max} - k}{k_{max}} + w_{final} \quad (7)$$

It provides a space for unseen particles to have movement and see other similar particles. More regions combine to each other and this will reduce the number of particles and region. The random characteristic of velocity has been updated using equation (6) to help more regions and particles. Although this will help to see other particles and regions and it will eventually cause that some pixels could not be seen even after a considerable number of iterations regarding the thresholding value, φ. To overcome this problem all ungrouped pixels are detected and then the distance to all existing regions is calculated and the closet regions to join the ungrouped particles.

D. Background Elimination

Thresholding has been carried out by originally computing the total variance of the whole image by considering all the pixels. The total variance computed is used as an initial threshold.

$$v = \sum_{i \varepsilon Q} \frac{(m - x(i))^2}{|Q-1|} \quad (8)$$

Where v total variance, m is mean of the pixels in the image and *x(i)* each pixel from the set of pixels Q. This threshold is optimized by using IPSO algorithm. The calculated total variance is used as initial global best to start and examine of threshold. Foreground and background ratio (fbratio) with the initial global best is calculated, fbratio is used as the feature which corresponds to the position and velocity of basic procedure of IPSO algorithm. Now all the variance among the pixels corresponding to each intensity level of an image is computed and with that variance corresponding feature is also computed. Two best values are updated using IPSO method that is pbest and gbest. pbest particle keeps track of its coordinates in the solution space which are associated with the best solution that has reached so long by that particle. This particle value is called personal best, which named as pbest. The value obtained so far us any particle in the neighborhood of that particle. This value is called global best. The outcome of the image segmentation process is a collection of segments which combine to form the entire image.

E. Improved Particle Swarm Optimization (IPSO) Method for Color Image Segmentation

The individual components of the object regions from the original color image are extracted. The procedure of IPSO method is given in the following flow diagram:

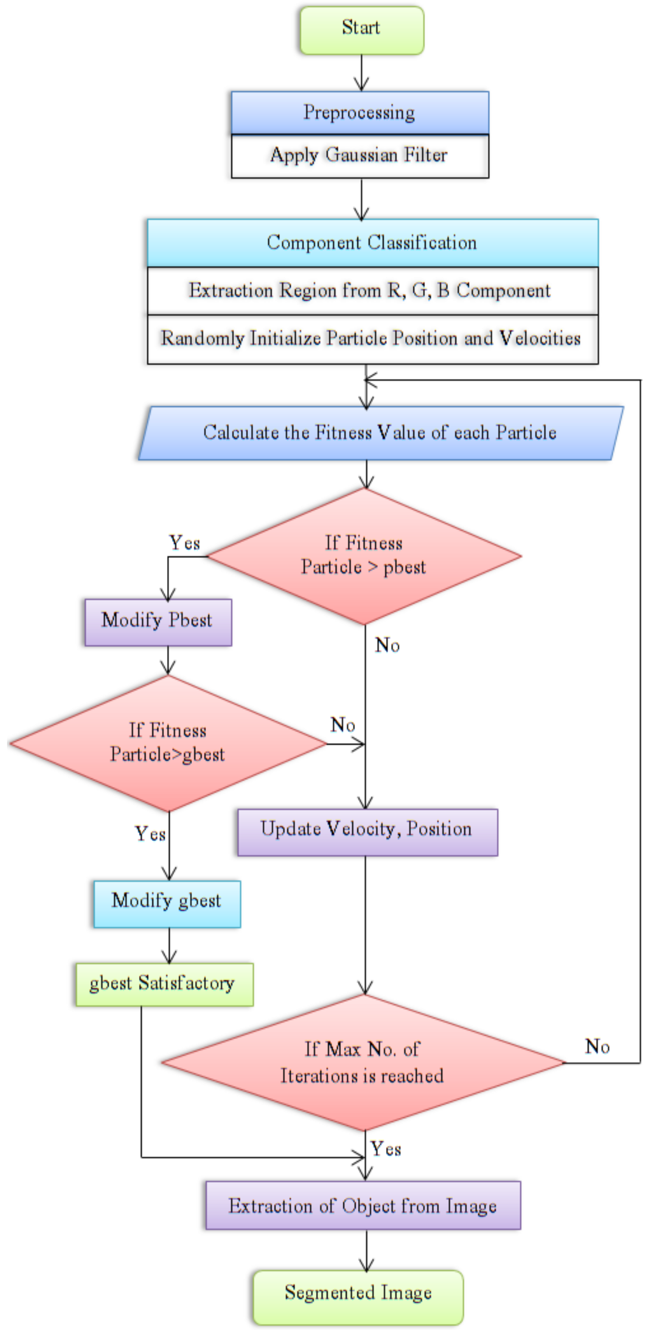

Figure 1. *Proposed IPSO Method*

Algorithm (IPSO)

Step 1: Select a color image

Step 2: From the color image separate R, G and B Components

Step 3: Extract the each component regions of the image

Step 4: Compute the total Variance

Step 5: Apply PSO method to the image with a particular threshold level

Step 6: For each particle in the population do
Update particle's fitness in the search space and
Update particles best in the search space
Move particle in the population

Step 7: For each particle do
If swarm gets better than reward the swarm
Spawn the particle: Extend the swarm particle life

Step 8: For each particle do
If swarm is not improving its performance then punish swarm
Delete the swarm particle: or reduce the swarm life

Step 9: Extend the swarm to spawn

Step 10: Delete the failed swarm and repeat the step 5.

Step 11: Recompute the region having the shortest path

Step 12: Extraction object from Image

Step 13: Finally get the segmented image.

IV. RESULTS AND DISCUSSION

The experiments use a variety of three sample color images containing single and multiple objects. The input color images have different types of dimensions. Such as Pepper (225 X 225), Flower (555 X 500) and Horse (350 X 239). The proposed IPSO method is tested for different parameters. The experiment is implemented through Matlab R2013a. The performances are,

(i) Accuracy = (TP+TN) / (TP+TN+FP+FN) (9)

Where,

TP (True Positive), TN (True Negative), FP (False Positive), FP (False Negative)

The true positive is the number of foreground pixels that are detected as foreground and true negative is the number of background pixels that are detected as background. The false positive is the number of background pixels that are incorrectly detected as foreground and false negative is the number of foreground pixels that are incorrectly detected as background.

PSNR is most commonly used to measure the fidelity of processed image to the original image. PSNR shows the similarity of an image against a reference image based on the mean square error of each pixel.

$$\text{PSNR} = 20 \log_{10}\left(\frac{255}{MSE}\right) \quad (10)$$

$$\text{MSE} = \frac{1}{m*n}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[x(i,j) - y(i,j)]^2$$

The proposed IPSO method is compared with two existing methods of Particle Swarm Optimization (PSO) and OTSU. The Figure 2, row 1 shows the original image, row 2 shows the OTSU method, row 3 shows the PSO method and row 4 shows the segmented image of the proposed method of IPSO. Table 1 and 2 shows accuracy and PSNR values are compared with existing methods of PSO, OTSU and the proposed method of IPSO. The proposed improved particle swarm optimization method gives better expected result while comparing with other two existing methods.

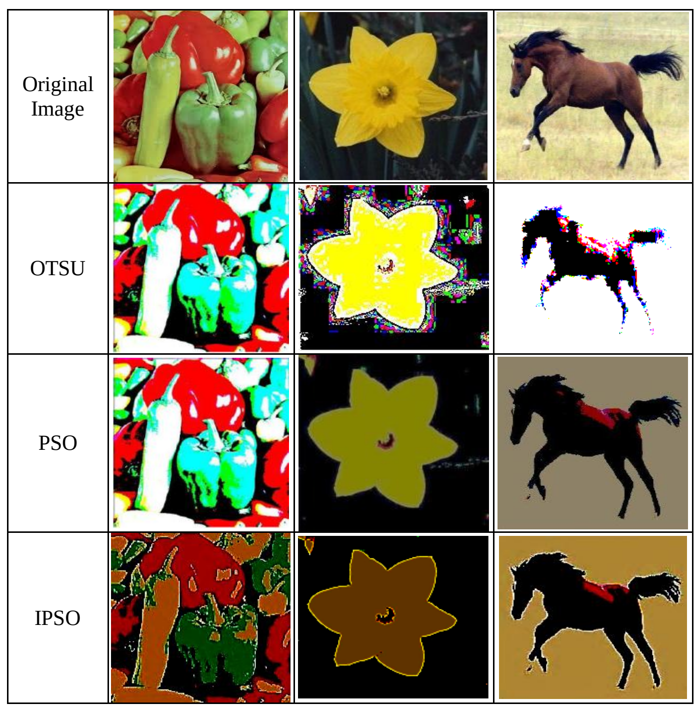

Figure 2. *Comparison of Images*

Table 1. Comparison Table for Accuracy

Images/ Methods	Accuracy (%)		
	OTSU	PSO	IPSO
Pepper	77	83	90
Flower	80	84	92
Horse	79	85	93

Table 2. Comparison Table for PSNR

Images/ Methods	PSNR Values		
	OTSU	PSO	IPSO
Pepper	25.0371	25.5330	27.5417
Flower	24.7223	26.0163	28.9448
Horse	24.7382	26.2328	28.8647

V. CONCLUSION AND FUTURE SCOPE

This paper presents proposed IPSO method to evolve background elimination by searching the optimized threshold form the available feasible thresholds which is a variance based approach of segmentation. The performance of the proposed method is evaluated in terms of accuracy and PSNR for three different color images. The experimental results show that as compared with the existing methods, the proposed method achieves high accuracy for image segmentation. The results show that the proposed method has the potential to achieve good performance across single and group of images. However, segmentation method still has some difficulties in accurately segment the object with complex background images. In future, different types of images and more informative features can be added to the feature set to improve the performance.

REFERENCES

[1] Akhilesh Chander, Amitava Chatterjee and Patrick Siarry, "*A New Social and Momentum Component adaptive PSO Algorithm for Image Segmentation*", Expert Systems with Applications, Elsevier, Vol.38, Issue. 5, pp. 4998-5004, 2011.

[2] Anita Tandan, Rohit Raja and Yamini Chouhan, "*Image Segmentation based on Particle Swarm Optimization Technique*", International Journal of Science, Engineering and Technology Research (IJSETR), Vol. 3, Issue. 2, pp.257-260, 2014.

[3] A.Borji, M.Hamidi and A.M.Eftekhari Moghadam, "*CLPSO-Based Fuzzy Color Image Segmentation*", IEEE, pp. 508-513, 2007.

[4] E.Boopathi Kumar and V.Thiagarasu, "*Color Channel Extraction in RGB Images for Segmentation*", 2nd International Conference on Communication and Electronics Systems(ICCES), IEEE, ISBN: 978-1-5090-5013-0, pp. 234-239, 2017.

[5] Chenxue Wang and Junzo Watada, "*Robust Color Image Segmentation by Karhunen-Loeve Transform based Otsu Multi-thresholding and K-means Clustering*", Fifth International Conference on Genetic and Evolutionary Computing, IEEE, pp.377-380, 2011.

[6] Chi-Yu Lee, Jin-Jang Leou and Han-Hui Hsiao, "*Saliency-Directed Color Image Segmentation using Modified Particle Swarm Optimization*", Signal Processing, Elsevier, Vol. 92, pp. 1-18, 2012.

[7] Dipak Kumar Kole and Amiya Halder, "*An Efficient Dynamic Image Segmentation Algorithm using A Hybrid Technique based on Particle Swarm Optimization and Genetic Algorithm*", International Conference on Advances in Computer Engineering, IEEE, Computer Society, pp. 252-255, 2010.

[8] Firas Ajil Jassim, Fawzi H. Altaani, "*Hybridization of Otsu Method and Median Filter for Color Image Segmentation*", International Journal of Soft Computing and Engineering (IJSCE), ISSN: 2231-2307, Vol. 3, Issue 2, 2013.

[9] Kajal Gautam and Rahul Singhai, "*Color Image Segmentation using Particle Swarm Optimization in Lab Color Space*", International Journal of Engineering Development and Research (IJEDR), Vol.6, Issue. 1, pp. 373-377, ISSN: 2321-9939, 2018.

[10] Kiran Ashok Bhandari and Manthalkar Ramanchandra R, "*A New Watershed Segmentation (NWS) and Particle Swarm Optimization (PSO-SVM) Techniques in Remote Sensing Image Retrieval*", Proceedings of 3rd International conference on Reliability, Infocom Technologies and Optimization, ISBN: 978-1-4799-6895-4, IEEE, 2014.

[11] H.Li, H.He and Y.Wen, "*Dynamic Particle Swarm Optimization and K-Means Clustering Algorithm for Image Segmentation*", International Journal for Light and Electron Optics, Vol.126, Issue 24, pp.4817-4822, 2015.

[12] Manas Yetirajam and Pradeep Kumar Jena, "*Enhanced Color Image Segmentation of Foreground Region using Particle Swarm Optimization*", International Journal of Computer Application, Vol. 57, No. 8, pp.18-23, 2012.

[13] Molka Dhieb, Sobeur Masmoudi, Mohamed Ben Messaoud and Faten Ben Afria, "*2-D Entropy Image Segmentation on Thresholding Based on Particle Swarm Optimization*", 1st International Conference on Advanced Technologies for Signal and Image Processing (ATSIP'2014), pp.143-147, March 17-19, 2014.

[14] D.Napoleon, A.Shameena and R.Santhoshi, "*Color Image Segmentation using OTSU Method and Color Space*", IJCA Proceedings on International Conference on Innovation in Communication, Information and Computing (ICICIC), No. 1, 2013.

[15] Parag Puranik, Preeti Bajaj, Ajith Abraham, Prasanna Palsodkar and Amol Deshmukh, "*Human Perception-Based Color Image Segmentation using Comprehensive Learning Particle Swarm Optimization*", 2nd International Conference on Emerging Trends in Engineering & Technology, IEEE, ISBN: 978-1-4244-5250-7, 2009.

[16] Saeed Mirghasemi, Ramesh Rayudu and Mengjie Zhang, "*A New Image Segmentation Algorithm Based on Modified Seeded Region Growing and Particle Swarm Optimization*", 28th International Conference on Image and Vision Computing, IEEE, pp. 382-387, 2013.

[17] M. Sezgin, B. Sankur, "*Survey over image thresholding techniques and quantitative performance evaluation*", J. Electron. Imaging, Vol. 13, No. 1, pp. 146-165, 2004.

[18] Shima Afzali, Bing Xue, Harith Al-Sahaf and Mengjie Zhang, "*A Supervised Feature Weighting Method for Salient Object Detection using Particle Swarm Optimization*", IEEE Symposium Series on Computational Intelligence (SSCI), ISBN: 978-1-5386-2727-3, 2017.

[19] A. A. Younes, I. Truck, and H. Akdaj, "*Color Image Profiling Using Fuzzy Sets*," Turk J Elec. Engin., Vol.13, No.3, 2005.

[20] Zhang Xue-Xi and Yang Yi-Min, "*Hybrid Intelligent Algorithms for Color Image Segmentation*", Chinese Control and Decision Conference(CCDC), IEEE, pp.264-268, 2008.

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