iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 **Issue:** X **Month of publication:** October 2023

DOI: https://doi.org/10.22214/ijraset.2023.56189

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue X Oct 2023- Available at www.ijraset.com

Multilevel Thresholding Segmentation based on Levy-Horse Optimization Algorithm: A Review

Mr. Machchhindra Jibhau Garde [1], Dr. Pravin Sahebrao Patil[2]
[1]*Research Scholar,* [2]*Professor, Department of E & TC Engineering SSVPS, Dhule, Maharashtra, India*

Abstract: ***A novel multi-level thresholding segmentation algorithm is proposed concerning machine learning and a metaheuristic algorithm is used to select multiple threshold value for segmenting the image. Here for the analysis, two, three and five-level of threshold value for the segmentation process is made.***
The threshold values for two, three and five level is generated by Levy horse optimized support vector machine (LHSVM). This optimized machine learning approach selects a reduced error threshold value to segment every object or region of interest in an image. Then the method is evaluated using Berkeley segmentation dataset and benchmark (BSDS300) dataset. This kind of multi-level threshold segmentation splits the image into class and thereby considers several classes for segmenting each object in the image.
Keywords: Levy horse based support vector machine, multi-level thresholds.

I. INTRODUCTION

In many image processing applications, the grey levels of pixels belonging to an object are substantially different from those belonging to the background [1].
As such, thresholding techniques can be used to extract the objects from their background [2]. Indeed, thresholding is a major operation in many image processing applications such as document processing, image compression, particle counting, cell motion estimation and object recognition [3]. The effect of many image processing applications strongly depends on the effect of image thresholding. T
hresholding techniques provide an efficient way, in terms of both the implementation simplicity and the processing time to perform image segmentation [4]. However, the automatic selection of a robust optimum threshold has remained a challenge in image segmentation. Besides being segmentation on its own, thresholding is frequently used as one of the steps in many advanced segmentation methods [5].
Segmentation is a technique decomposing an image into meaningful parts, or objects. Most computer vision and image analysis problems require a segmentation technique as a pre-processing stage in order to detect objects or divide the image into regions, which can be considered homogeneous according to a given criterion, such as colour, motion, texture, and etc. [6]. The image thresholding is widely used in halftone reproduction [7], infrared image segmentation [8], automatic target recognition [9], colour image segmentation [10] and mixed-type document analysis [11].
Single or Multilevel thresholding is an effective approach for image segmentation. Bi-level thresholding selects only one threshold which separates the pixels into two classes, while multilevel thresholding determines multiple thresholds which divide the pixels into several groups.
Thresholding techniques can be classified into two types: optimal thresholding methods and property-based thresholding methods [12]. Optimal thresholding methods search for the optimal thresholds which make the thresholder classes on the histogram Property-based thresholding methods are fast and suitable for the case of multilevel thresholding, while the number of thresholds is hard to determine and should be specified in advance.
In recent years, Swarm Intelligence (SI) methods received wide attention since they are applied in different areas and applications of Economics, Chemistry, and Medicine [13]. Moreover, the SI approaches are applied in different image processing fields, such as computer vision, face recognition, object identification, etc.
There are different methods for optimization, includes Particle Swarm Optimization (PSO) [14], Ant Colony Optimization (ACO) [15], Artificial Fish Swarm Algorithm (AFSA) [16] and Bee Colony [17, 18] are the most well-known algorithms have ever been proposed for optimization.

II. LITERATURE REVIEW

Among the numerous research works related to thresholding, some of the most recent research works are reviewed here in this section.

1) Singh (2020) et.al in [19], LebTLBO is applied on ten standard test images having a diverse histogram, which are taken from Berkeley Segmentation Dataset 500 (BSDS500) benchmark image set for segmentation. The search capability of the algorithm was combined with Otsu and Kapur's entropy MT objective functions for image segmentation. The proposed approach was compared with the existing state-of-the-art optimization algorithms such as MTEMO, GA, PSO and BF for both Otsu and Kapur's entropy methods. Qualitative experimental outcomes demonstrate that LebTLBO is highly efficient in terms of performance metrics such as PSNR, mean, threshold values, number of iterations taken to converge and image segmentation quality.

2) Pare, (2018) et.al in [20] has proposed, a modified fuzzy entropy (MFE) function to perform the multilevel thresholding of color images at different segmentation levels using Lévy flight guided firefly algorithm (LFA). Modified fuzzy entropy function is the difference of adjacent entropies. Therefore, minimizing the fitness function will provide thresholding levels such that all the regions have almost equal entropies. LFA algorithm improves the search performance and gains optimal threshold values for an efficient segmentation of colored images and satellite images. A comparative study of different nature inspired algorithms using MFE as an objective function presented. The study proves that the proposed MFE-LFA algorithm exhibits better performance in terms of different fidelity parameters and computation time. In addition, the proposed method was also compared with the most widely used Kapur's entropy-based segmentation approaches, where the simulation results show the proposed methodology as the most efficient and effective algorithm.

3) Abd Elaziz (2020) et.al in [21] has presented an enhanced Harris Hawks Optimizer (HHO) to tackle global optimization and determine the optimal threshold values for multi-level image segmentation problems. HHO was a new swarm-based metaheuristic technique that simulates the behaviours of Harris hawks during the process of catching the rabbits. The HHO established its strong performance as a swarm-based optimization technique. However, population-based HHO still may face some limitations in dealing with more multimodal and composition problems. For example, this optimizer may be stagnated to local optima and turned to immature convergence when performing phases of exploration and exploitation. To mitigate these drawbacks, an improved HHO was proposed that considers the salp swarm algorithm (SSA) as a competitive method to enhance the balance between its exploration and exploitation trends. Firstly, a set of solutions was generated. Then, they divide those solutions into two halves, where the exploratory and exploitative phases of HHO will be applied to the first half, and the searching stages of SSA will be used to update the solutions in the second half. Thereafter, the best solutions from the union subpopulations are selected to continue the iterative process. According to the improved HHO, which is called HHOSSA, an effective multi-level image segmentation approach is also developed in this research. A comprehensive set of experiments are performed using 36 IEEE CEC 2005 benchmark functions and 11 natural gray-scale images. Extensive results and comparisons show the high ability of the SSA to improve the HHO's performance since the proposed HHOSSA achieves a more stable performance compared to HHO, SSA, and many other well-known methods.

4) Abd El Aziz et.al in [22] has proposed a new method for determining the multilevel thresholding values for image segmentation. The proposed method considers the multilevel threshold as multi-objective function problem and used the whale optimization algorithm (WOA) to solve this problem. The fitness functions which used are the maximum between class variance criterion (Otsu) and the Kapur's Entropy. The proposed method uses the whale algorithm to optimize threshold, and then uses this thresholding value to split the image. The experimental results showed the better performance of the proposed method to solving the multilevel thresholding problem for image segmentation and provided faster convergence with a relatively lower processing time.

5) Resma (2018) et.al in [23] has proposed a novel multilevel thresholding algorithm using a meta-heuristic Krill Herd Optimization (KHO) algorithm for solving the image segmentation problem. The optimum threshold values are determined by the maximization of Kapur's or Otsu's objective function using Krill Herd Optimization technique. The proposed method reduces the computational time for computing the optimum thresholds for multilevel thresholding. The applicability and computational efficiency of the Krill Herd Optimization based multilevel thresholding is demonstrated using various benchmark images. A detailed comparative analysis with other existing bio-inspired techniques based multilevel thresholding techniques such as Bacterial Foraging (BF), Particle Swarm Optimization (PSO), Genetic Algorithm (GA) and Moth-Flame Optimization (MFO) has been performed to prove the superior performance of the proposed method.

Table 1. Comparative analysis for multi-level thresholding image segmentation

Author and Year	Method	Merits	Demerits
Mousavirad et al. [2021]	HCS-BBD	Optimal threshold values such as 5 and 10 are obtained with 25 iterations	The method is computationally expensive
Ren et al. [2022]	MGSMA	2D-kapur's entropy is sued to attain optimal threshold values	Failed on degraded images
Liu et al. [2022]	MROA	Opposition based learning is used to select the opposition best solution	Consume more CPU time when the threshold levels are increased
Elaziz et al. [2020]	HHOSSA	The best solution is obtained from the sub-population on each iteration	More execution time and the images are segmented clearly
Sharma et al. [2022]	OIF	The fuzzy parameters are optimized using the meta-heuristic algorithm to achieve an enhanced image segmentation	Ineffective optimization algorithm

III. PROPOSED METHODOLOGY

Thresholding method is a simple and effective tool to isolate objects of interest from the background. Its applications include several classics such as document image analysis, whose goal is to extract printed characters logos, graphical content, or musical scores; also, it is used for map processing which aims to locate lines, legends, and characters. It is also used for scene processing, aiming for object detection and marking. Similarly, it has been employed to quality inspection for materials discarding defective parts.

Multilevel thresholding has been long considered as one of the most popular techniques for image segmentation. Multilevel thresholding outputs a grey scale image in which more details from the original picture can be kept, while binary thresholding can only analyse the image in two colours, usually black and white. However, two major existing problems with the multilevel thresholding technique are: it is a time-consuming approach, i.e., finding appropriate threshold values could take an exceptionally long computation time; and defining a proper number of thresholds or levels that will keep most of the relevant details from the original image is a difficult task [24].

Recently, there are several approaches have been applied for image segmentation, including edge detection, clustering algorithms, threshold segmentation, and region extraction. Threshold segmentation methods can be categorized in two categories, namely bi-level and multi-level segmentation. The bi-level methods groups image objects into two classes. If the number of classes is more than two, multi-level method is applied. The multi-level method splits an image's pixel into several classes based on the intensity. Several existing studies used the image histogram to obtain the best threshold value by minimizing or maximizing the fitness functions, such as Kapur's entropy and Otsu. In recent years, different Meta Heuristic algorithms have been applied in the field of image segmentation, such as the firefly optimization algorithm (FA), harmony search (HS) algorithm, Multilevel Image Thresholding Based on Hybrid SSA and Fuzzy Entropy bee mating optimization (HBMO), particle swarm optimization (PSO), artificial bee colony (ABC) and cuckoo search (CS) algorithm. However, these traditional models that have been used to find the optimal threshold value is very time-consuming because of the inefficient formulation between the class variance. In order to address these limitations, meta-heuristic (MH) approaches have been used [25,26].

IV. RESULT AND DISCUSSION

Thresholding is a popular image segmentation method that converts grey-level image into binary image. The selection of optimum thresholds has remained a challenge over decades. In order to determine thresholds, most methods analyse the histogram of the image. The optimal thresholds are often found by either minimizing or maximizing an objective function with respect to the values of the thresholds.

1) Machine learning develops rapidly, which has made many theoretical breakthroughs and is widely applied in various fields. Optimization, as an important part of machine learning, has attracted much attention of researchers.
2) The systematic retrospect and summary of the optimization methods from the perspective of machine learning are of great significance, which can offer guidance for both developments of optimization and machine learning research.
3) In this proposed work, we first describe the optimization problems in machine learning, a new intelligence algorithm, is presented for multilevel thresholding in image segmentation.

4) In this work, an enhanced machine learning framework is established for an effective image segmentation. The core of this framework is to adopt Horse optimization algorithm (HOA) enhanced by Levy flight (LF) strategy (LF-HOA) to optimize the key parameters of support vector machine (SVM) and build LF-HOA based SVM (LFOA-SVM) for multilevel thresholding in image segmentation [27, 28].

5) To evaluate the performance of the proposed methodology, we evaluated our techniques on standard benchmark dataset [27]. Our evaluation results of the proposed method will outperforms traditional GA, PSO, SSA and MFO algorithms, in terms of PSNR, SSIM and fitness value.

V. CONCLUSION

In this paper, Image segmentation using thresholding algorithms are discussed. It is categorized in two parts Levy horse based support vector machine, multi-level thresholds. A Levy Flight (LF) enhanced Horse optimization algorithm (HOA) method will implement in this research and it is able to provide accurate segmentation results for each image that was tested.

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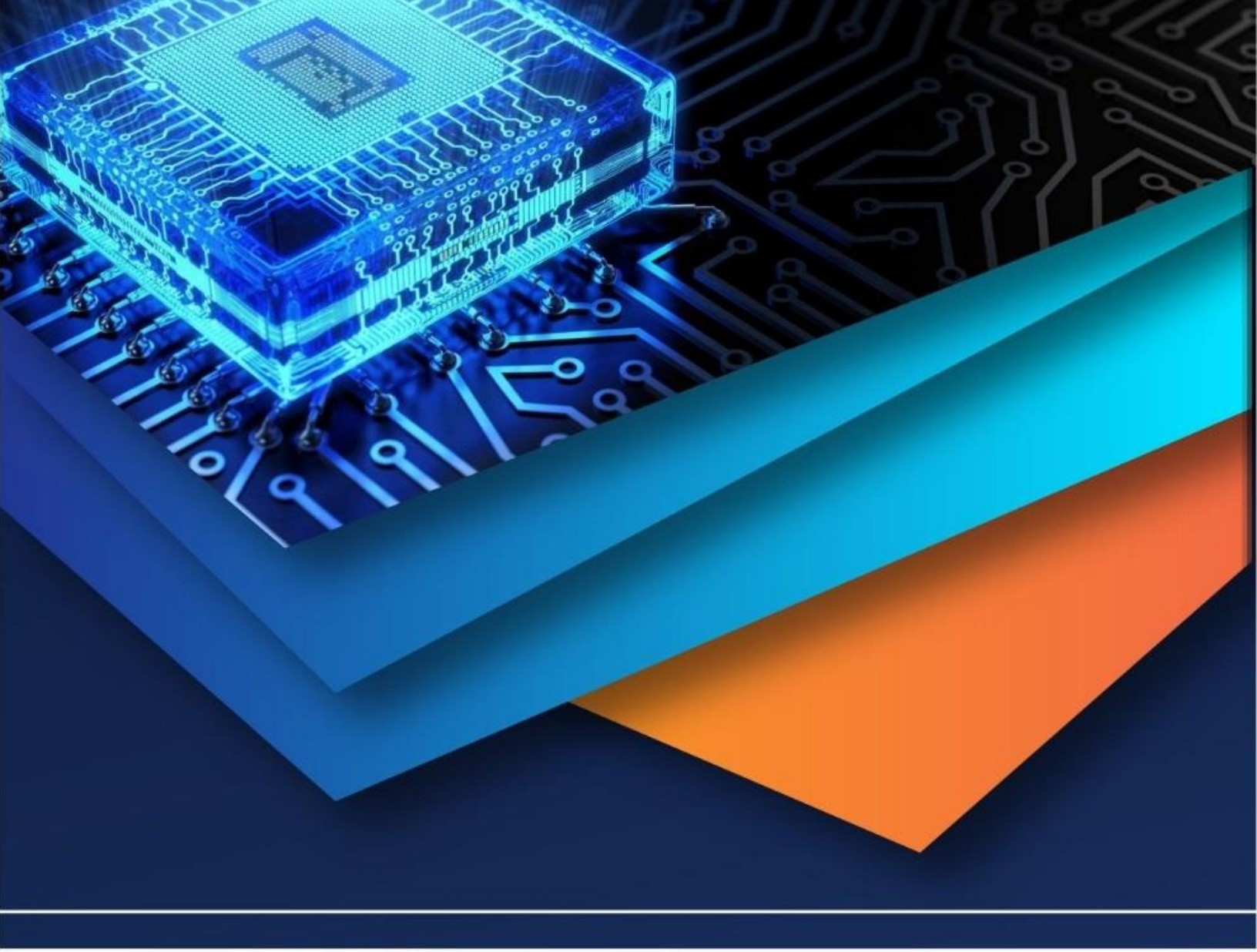

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