A Critical Review on Nature Inspired Optimization Algorithms

Vishnu Soni¹, Abhay Sharma¹ and Vijander Singh²
¹Computer Science Department, Amity University Rajasthan, Jaipur, India
²Department of Computer Science and Engineering, School of Computing and Information Technology, Manipal University Jaipur, Rajasthan, India

E-mail: vishnusoni2221991@gmail.com

Abstract. Nature-inspired optimization algorithms turned out to be progressively more accepted in modern era, and the majority of these meta-heuristic algorithms, such as ‘Bat algorithm’, ‘Lion Algorithm’, ‘Particle swarm optimization’, ‘Water wave optimization algorithm’, ‘Elephant herding optimization algorithm’, ‘Optics inspired optimization algorithm’, ‘Cuckoo search’, ‘Flower algorithms’, ‘Genetic algorithms’, ‘Differential evolution’, ‘Harmony search’, ‘Simulated annealing’, and many more. This paper attempts to establish the most recent improvements concerning all main ‘Nature-Inspired Algorithms’ and it is strived to coat at least one hottest optimization problem related to these above-mentioned algorithms. Based on their outcomes it is established that there are a few considerable gaps between hypothesis and observe. On one side, nature-inspired algorithms for optimization are extremely successful and can acquire most favourable clarifications in a convincingly realistic time. On the other side, mathematical investigation of key characteristics of these algorithms is missing. It is extremely advantageous that researchers add on some impending into the neutrality of diverse nature-inspired algorithms and hence can obtain the dare to crack key difficulties that must be solved. The paper is extending extensively and intensifying the need to evaluate and review these various optimization algorithms. This paper is organized in a manner to provide complete description of each NIA starting from introduction then review of literature, analysis of various NIAs and finally conclusion.

1. Introduction
The computationally comprehensive and essentially time-consuming portion is recognized as Motion Estimation (ME). ME procedure can be observed as an ‘Optimization Problem’ where investigation is accepted in a predefined search region to establish the ‘Identical Macro-Block’ (MB) subsequent to each MB by minimizing the ‘objective function cum search criterion’ as least value of ‘search criterion’ recognize the location of the preeminent harmonizing MB.

Due to the appearance of a range of “Nature-Inspired Algorithms” (NIAs) as mentioned below like Genetic Algorithm (GA), Bat Algorithm, Particle swarm optimization, Lion Algorithm, Water Wave Optimization Algorithm (WWO), Optics Inspired Optimization Algorithm (OIO), Elephant Herding Optimization Algorithm (EHO), Harmony Search (HS), Cuckoo Search, Differential Evolution (DE), Flower Algorithms, Simulated Annealing (SA), etc and their relevance in optimizing the entire category of daily problems has unwraped an innovative era in the domain of ME. The objective of this paper is to compare the above mentioned NIA algorithms on the basis of various parameters and
depending on these parameters results so obtained will be discussed to show the nature of these algorithms can be seen in figure 1.

![Diagram of Different NIAs](image)

**Figure 1.** Classification of Different NIAs

### 2. Review Articles

The below mentioned review is presented according to the algorithms mentioned above. Like Water Wave Optimization Algorithm (WWO), Bat Algorithm, Particle swarm optimization, Optics Inspired Optimization Algorithm (OIO), Lion Algorithm, Elephant Herding Optimization Algorithm (EHO), Harmony Search (HS), Genetic Algorithm (GA), Cuckoo Search, Differential Evolution (DE), Flower Algorithms, Simulated Annealing (SA) have been discussed.

Xin-She Yang & Xingshi He, in 2013 addressed that the Bat algorithm (BA) is termed as “Bio-Inspired Algorithm” that had been urbanized in 2010 and the algorithm has been established extremely proficient [1]. The ‘echolocation characteristics’ of micro-bats have been utilized in this BAT Algorithm. It also utilizes “frequency-tuning technique” to amplify the multiplicity and at that identical moment, it employs the repeated burning to equitably investigation & operation at the time of explore practice by imitate dissimilarities of ‘Pulse Emission Rates’ and Intensity of Sound of bats while penetrating for prey. As an outcome, it establishes to be very resourceful with a distinctive speedy initiate. Apparently, there is scope for enhancement. Consequently, this manuscript proposed to appraise the most recent improvements of this Bat algorithm. In accumulation, prelude conjectural investigation recommended that Bat algorithm has guaranteed ‘Global convergence’ belongings to the correct circumstances and Bat algorithm can also resolve extensive troubles efficiently. BAT algorithm has the benefits of effortlessness & litherness. Bat algorithm is simple to execute, and an uncomplicated algorithm can be extremely lithe to resolve an extensive choice of difficulties, as we have seen in the above evaluation.

M. Mohammed Thaha, et.al in 2019 worked on Brain Tumour Segmentation by means of BAT algorithm [2]. They recommended that the development of diagnosing the brain tumours by the general practitioner is usually approved by means of a physical means of segmentation. This algorithm is instant overwhelming and a problematical one also. To resolve both troubles, the new technique known as “Enhanced Convolutional Neural Networks” is planned by means of ‘Loss Function Optimization’ with the use of BAT algorithm designed for repeated segmentation technique. The
prime mean was en-routed for representation of optimization based MRIs image segmentation. Miniature kernels consent was proposed for deep planning. It has constructive outcomes with reference to over fitting presented the slighter weights are allocated to the network. The investigational outcomes show the improved concert while comparing with the accessible techniques. The evaluated constraints are exactitude, recollect and precision. In prospect, unusual selecting formats can be approved to progress the precision. The Enhanced Convolutional Neural Networks with ‘Loss Function Optimization’ as a result of BAT Algorithm was organized in-order to accomplish segmentation of MRI image by mean of a usual performance. Miniature kernels are wormed to accomplish a profound planning. In upcoming work various ‘diverse selecting schemes’ can be espoused to convalesce the correctness.

They utilized some CNN rules for following parameters:

\[
\begin{align*}
\text{Accuracy} &= \frac{TP + TN}{TP + TN + FP + FN} \\
\text{Score} &= \frac{2 \times TP}{2 \times TP + FN + FP} \\
\text{Precision} &= \frac{TP}{TP + FP} \\
\text{Sensitivity} &= \frac{TP}{TP + FN} \\
\text{Specificity} &= \frac{TN}{TN + FP}
\end{align*}
\]

Maziar Yazdani, Fariborz Jolai in 2015 explained complex optimization troubles with ‘meta-heuristic algorithms’ recognized as lion optimization algorithm [3]. Extraordinary life style of lions and their collaboration personalities had impetus for expansion of this optimization algorithm. Some standard troubles were preferred from the review, and the clarification of the projected algorithm as been evaluated with those of several well-known and latest meta-heuristics for these troubles. The achieved outcomes authenticate the elevated performance of the projected algorithm in evaluation to the additional algorithms used in this paper. LOA is produced based on recreation of the private and supportive activities of lions such as prey confines, mating, defense and some additional manners.

Xiaogang Li and Mingyan Jiang in 2020 deliberated an ‘Improved Lion Swarm Optimization’ (ILSO) Algorithm utilized specially in support of “Multi-Threshold Image Segmentation” [4]. They have been operated to representation and outline the amount of occasion an entity collapses into the confined optimal and assuage it so. The utmost inter-class divergence customary is favoured as the “Fitness Function” to fault the ‘Multi- doorway representation segmentation’ complexities by ILSO. The multiplication rate was better and matched up in the course of the inventive LSO Algorithm. The improved lion cluster Algorithm planned here can hurriedly and successfully appreciate image segmentation and attain ideal segmentation upshot for multi-doorstep image segmentation.

Netra M Lokhande, Ramachandra V. Pujeri in 2018 presented their paper to develop the image segmentation by means of nature inspired methods [5]. Image segmentation is known as composite optimization problem which can be unravelled by this straightforward nature inspired PSO (Particle swarm optimization) representation which was originated in this paper. PSO model is nonspecific replica which is utilized to explain number of systematic problems. This paper formulated uncomplicated PSO model to solve the image segmentation difficulties. The projected algorithm arbitrarily allocates the centers to swarm and preeminent significance of objective function is initialized best on the color histogram of an image. An adaptive clustering algorithm was used to perceive the number of centers vigorously can also be discovered with various amendments in presented PSO algorithm.
Yu-Jun Zheng in 2015 presented a burning issue in scientific and engineering fields. Encouraged by mean of shallow water wave theory, this manuscript presented an original meta-heuristic technique, by name of Water Wave Optimization (WWO), for comprehensive optimization problems [6]. The algorithmic construction of WWO is uncomplicated, and straightforward to accomplish through small-size populace. The computational outcomes reveal that WWO is exceptionally cutthroat by way of state-of-the-art Evolutionary. The novel meta-heuristic was predictable to have extensive submission in real-world engineering optimization problems.

Juan Li et.al in 2020 used the ‘Elephant Herding Optimization’ (EHO) for herding manners of elephants. To amend the space of the elephants in every clan with admiration to the situation of a elephant clan operator is utilized. The incomparability of the EHO proposed to abundant state-of-the-art meta-heuristic. An inclusive assessment has been presented in this manuscript [7]. This algorithm has incorrigible and a hopeful means for several optimization problems and manufacturing submissions. Frequent attributes of EHO technique should be additionally studied as mentioned below.

1) Most investigators have basically payed attention on the optimization conclusion of EHO.
2) Consume EHO to respond unsettled optimization hitches.
3) Hybridizing EHO through various algorithm constituents.
4) EHO has accomplished some extraordinary undertakings.

Li Zhang & Chee Peng Lim in 2020 proposed optics inspired Optimization (OI) superior collection of cavernous neural networks designed for optic disc (OD) segmentation by means of retinal images. The proposed assembly system is appraised with in-cooperation of the original and state of the art OI alternatives [8].

Additionally, it is competent to promote and increasing explore diversification by conveying an individual search accomplishment to each element in any iteration. The enhanced performances are shown throughout arithmetical test effects.

E. Ben George et.al in 2015 presented Cuckoo Search (CS) algorithm considered as basic observation of cuckoo search algorithm [9]. It has been noticed that the human brain is essentially combined agreement were labelled the tumour like diseases. The tumour possibly will take place with comparable deliberation of standard tissues. This manuscript explored the CS Algorithm to establish how it is competent in classify tumours and approximate the cost with the optimization algorithms.

Metkar in 2020 ascertained an imperative attribute from image is removed by using image processing instruments. Segmentation Algorithms are categorized and depended on gloom, gray values or textures of an image. In this manuscript, she offered Diverse Segmentation Algorithms next to with her experimental outcomes [10]. It was accomplished that the “Quad Tree & Merger Algorithm” and Global Thresholding Algorithm was repeatedly suitable for essential images.

Chong Tan et.al in 2019 confirmed that Image segmentation acquaintance is one of the crucial vicinity in the field of digital image processing. Nevertheless, there was no identical customary for accessible image segmentation techniques, and the conventional image segmentation scheme is only appropriate for several exact circumstances [11]. Therefore, it was extremely imperative to research and develop new hypothesis and schemes of image segmentation equipments.

Genetic algorithm is a technique for manipulative the best explanation by simulating the biological evolution progression in the usual collection and genetic apparatus of biological development. It has strapping robustness, parallelism, adaptability and fast convergence. The investigational consequences revealed that the image segmentation outcome based on genetic algorithm is better than the conventional image segmentation.
Veysel Aslantas & Mehmet Tunckanat in 2007 expressed the utilization of Differential Evolution Optimization Algorithm (DEOA) designed for segmentation of injury on the pelt. The potential degree of difference Evolution Optimization Algorithms consist of acceptance, straightforward functions by means of global optimal replicated to injury image segmentation [12].

The DEOA has an objective to concomitantly decline the quantization error $q_e$ and intra-cluster distances, and to capitalize on the inter-cluster expanses. The impending exertion will force a tailored DEOA that uneased the pixel neighbourhood relation. The investigational conclusion recommended that the predictable approach is bendable and is competent to construct a suitable segmentation outcome.

Laith Abualigah, et.al in 2020 presented Harmony Search Algorithm (HSA) in terms of Swarm Intelligence Optimization Algorithm (SIOA) ranging of huddling applications mutually through text clustering, data clustering, image processing, fuzzy clustering, and wireless sensor networks [13]. In their exploration they have measured articles wherein HSA has been realistic to a range of submissions; among them a lot of were interrelated with clustering. The concert of HSA is sturdily contingent on constriction directives.

Zoran Majcenic and Sven Loncaric in their manuscript exemplified a stochastic procedure for segmentation of CT head images by mean on simulated annealing (SA). In their estimated procedure the segmentation complexities were recognized as the pixel labelling trouble through marker skull and brain tissue The considered procedure was depended on the Maximum “A-Posteriori MAP estimation. The MAP estimation of the segmented image has been unwavering by means of the simulated annealing algorithm. Investigational outcomes have confirmed superior products and established the usability of the system [14].

Liqun Tang et.al in 2007 Optimized Segmentation Algorithm (OSA) depended on the Simulated Annealing (SA) and the enhanced ‘Snake Model’ was predictable. In that enhanced ‘Snake Model’, the centre-energy is further added on the predictable snake model and curl force can be attuned according to the agreement of the dot. The boundary of the commentary can be presented on the proposed algorithm [15].

3. Analysis of Various Algorithms Investigated
The arithmetical investigation of these various algorithms presents a superior performance not only in terms of optimization of segmented images but additionally carry out minimization in a smaller amount of assessment of the above mentioned algorithms cost function. Even though the preeminent excellence performance of the meta-heuristic algorithms be in the right place in excellence terms but do not show the finest performance in segmentation terms. The obtainable biologically inspired algorithms (BIAs) are frequently worn for the optimization of SAD value to discover the most excellent and identical MB in the orientation outline and can be seen in table 1.
Table 1. Analysis of Various NIAs Based on Efficiency, Accuracy, Speed and Complexity

| NIA                  | Method Used                                | Parameters Analysed                      | Complexity                                      |
|----------------------|--------------------------------------------|------------------------------------------|-------------------------------------------------|
| BAT                  | Exploration & Exploitation                 | Efficient & Effective                    | Less complex and Easy to implement              |
| LOA                  | Simulation of Solitary and cooperative     | Efficient                                | Solved complex optimization problems           |
| PSO                  | Optimum clustering for Image Segmentation  | Moderate                                 | Solved complex optimization problems           |
| WWO                  | Real world high speed scheduling           | Efficient & Effective                    | Simple and Easy to implement                   |
| EHO                  | Clan Operator                              | Moderate                                 | Solved to multi objective optimization problems|
| OIO                  | Optic Disc segmentation using retinal      | Efficient & Effective                    | Increasing search diversity                     |
| CS                   | Segmentation of brain tumor                | Efficient & Effective                    | Differentiating the component of complex brain  |
| FA                   | Image extraction                           | Efficient & Effective                    | Less complex and better noise immunity         |
| GA                   | Image segmentation technology              | Efficient & Effective                    | Strong robustness, parallelism                  |
| DE                   | Segmentation of wounds on the skin         | Efficient & Effective                    | Flexible and capable to generate acceptable    |
| H.S.A.               | Swarm intelligence optimization            | Efficient & Effective                    | Allow for multi objective optimization         |
| SA                   | Stochastic method for segmentation         | Moderate                                 | Computationally Complex                         |

4. Conclusion
This analysis is centred on the relevance of every category of NIAs estimated for optimizing the ME procedure in terms of speed, accuracy, performance, convergence, efficiency and complexity. This analysis is try to investigate every category of NIAs and their methodologies all the way through a general study of their associated publications and enabled author to do a comprehensive assessment to emphasize the cutthroat improvement of “soft computing techniques” in excess of presented ‘pattern-
based algorithms’. This manuscript places places of interest on the preambles of significant algorithms, examination of major constituents of these algorithms. However, this paper doesn’t emphasize too much on the accurate accomplishment by means of programming languages. Investigator or researcher has strained a choice of encouragements to expand a various variety of algorithms with diverse level of success. In future Researcher can utilize any of the above-mentioned NIAs for their prospected work depending on their parameter and methodology selection.

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