

Review and Perspectives on Nature-Inspired Computational Algorithms

Manjiri U. Karande¹, Ankush S. Narkhede², Sudesh L. Farpat³, Madhuri R. Rajput⁴

^{1,2,3,4} *Asst. Professor, CSE department, Padm. Dr. V. B. Kolte College of Engineering, Malkapur, Maharashtra, India*

ABSTRACT

The integration of artificial intelligence into daily life is increasingly pervasive and unavoidable. In this expansive domain, nature-inspired algorithms play a crucial role in multiparameter optimization, with applications spreading across numerous fields. Optimization is essential in various sectors, including engineering, business operations, and industrial design. Bio-inspired computing serves as a comprehensive approach that intersects computer science, mathematics, and biology. In recent years, computer simulations have emerged as vital instruments for resolving optimization challenges using diverse and efficient search algorithms. Bioinspired computing optimization algorithms represent a growing field that draws upon the principles and inspirations derived from biological evolution to formulate novel and robust competitive methodologies. In recent years, these bio-inspired algorithms have gained recognition in the realm of machine learning for their capability to identify optimal solutions to complex scientific and engineering challenges. To overcome the limitations associated with traditional optimization methods, current trends favor the application of bio-inspired algorithms as a promising approach for addressing intricate optimization issues. This paper offers an examination of select nature-inspired algorithms alongside their potential applications.

Keyword - Optimization, nature-inspired optimization algorithms, Artificial intelligence, Swarm intelligence, metaheuristic algorithm

1. INTRODUCTION TO NATURE-INSPIRED COMPUTATIONAL ALGORITHMS

1.1 Definition and Scope of Nature-Inspired Algorithms

Nature-inspired computational algorithms refer to a broad class of optimization and problem-solving methods that draw inspiration from processes and behaviors observed in natural systems. These algorithms mimic biological, ecological, physical, and social phenomena to explore and exploit search spaces effectively, thereby addressing complex computational problems that are often resistant to classical optimization techniques. Unlike traditional optimization methods, which are typically deterministic and may rely heavily on gradient information or exhaustive search, nature-inspired algorithms leverage stochastic, adaptive, and population-based mechanisms to navigate complex solution landscapes with higher flexibility and robustness.

This class of computational methods encompasses various techniques such as genetic algorithms, swarm intelligence, evolutionary strategies, and other metaheuristics that simulate mechanisms like natural selection, social behavior of animals, or chemical reactions. Nature-inspired algorithms have gained increasing attention due to their efficacy in solving multi-objective and NP-hard problems where exact methods become computationally infeasible. Their adaptability to different problem domains and ease of hybridization further extend their applicability across diverse fields.

Several seminal classification efforts and surveys have aimed to organize the rapidly growing body of nature-inspired algorithms by categorizing them according to their biological or physical inspirations, algorithmic mechanics, and application domains. Such classifications help provide clarity regarding algorithm selection and research directions. The ongoing evolution of these methods continues to expand their scope beyond classic combinatorial optimization to domains involving multiparameter optimization and real-time dynamic environments [1].

1.2 Historical Development and Evolution

The development of nature-inspired algorithms can be traced back to early heuristic techniques that emulate evolutionary processes and collective behavior. Among the earliest and most influential are Genetic Algorithms (GAs), introduced in the 1970s, which model the principles of natural selection, mutation, and reproduction to evolve solutions over successive generations. Subsequently, Particle Swarm Optimization (PSO) emerged in the 1990s, inspired by the collective movement and foraging behavior observed in bird flocks and fish schools.

Over time, these foundational metaheuristics spurred the emergence of numerous hybrid and bio-inspired algorithms, including Ant Colony Optimization (ACO), Differential Evolution, and more recently developed strategies based on less explored biological phenomena. Adaptation mechanisms and parameter tuning have become increasingly central to the field to enhance convergence speed, balance exploration-exploitation, and improve solution quality. The sophistication of these algorithms has grown with incorporation of adaptive parameters, hybrid strategies combining complementary approaches, and the integration of domain knowledge.

The evolution of these metaheuristics reflects a response to the need for scalable, flexible optimization techniques capable of addressing diverse and complex problem environments. This progression is documented in comprehensive surveys highlighting the modulation and adaptation of classical algorithms and the rise of novel metaheuristics in the 21st century, marking an era of intense algorithmic refinement and hybridization [2], [1], [3].

1.3 Motivations and Applications Across Domains

Nature-inspired algorithms have found motivation in their ability to overcome the limitations of exact, gradient-based, or classical deterministic optimization methods, particularly for NP-hard and combinatorial problems that are intractable for exhaustive search. Their stochastic, population-based nature equips them to search large and complex landscapes efficiently while avoiding local optima, thus enabling practical solutions in fields requiring robust optimization under uncertainty or multiple conflicting objectives.

Applications span a broad spectrum of domains. In healthcare, these algorithms facilitate optimization in IoT-based healthcare services by improving resource allocation, sensor management, and predictive models. Agriculture benefits from their use in machinery path optimization, irrigation scheduling, pest detection, and yield enhancement. Industrial and engineering systems utilize these algorithms to resolve logistical, combinatorial, and design challenges intrinsic to supply chains, routing, and manufacturing. Their utility extends even into microelectronics and nanophotonics for the optimization of circuit designs and photonic structures.

Significantly, nature-inspired algorithms provide advantages over classical methods through their simplicity, ease of implementation, flexibility to address multi-objective formulations, and capability to integrate domain-specific constraints. However, despite their strengths, challenges such as algorithm integration, parameter tuning, standardized evaluation, and security—especially in IoT domains—motivate ongoing research and innovation [4], [5], [1].

2. CLASSIFICATION OF NATURE-INSPIRED ALGORITHMS

2.1 Swarm Intelligence-Based Algorithms

Swarm intelligence-based algorithms derive from the collective behavior of decentralized, self-organized systems such as insect colonies, bird flocks, or fish schools. These algorithms employ a population of agents (particles, ants, bees, etc.) that interact to explore the search space cooperatively, often through indirect communication mechanisms.

Particle Swarm Optimization (PSO), inspired by bird flocking, uses individual and social knowledge to guide particles towards promising regions. Ant Colony Optimization (ACO) mimics the pheromone-based path-finding behavior of ants, effective in discrete combinatorial problems such as routing. The Artificial Bee Colony (ABC) algorithm simulates the foraging behavior of honeybees, balancing exploration and exploitation via different bee roles. Less prevalent swarm algorithms include Firefly and Krill Herd algorithms, each based on distinctive biological interactions.

These algorithms are characterized by their distributed computation, adaptive parameter control, and ability to solve both continuous and discrete optimization problems. Their typical applications include network routing, scheduling, resource allocation, and environmental monitoring, where decentralized decision-making and

robustness are crucial. In agriculture, specific swarm algorithms like ACO and PSO have found practical use for optimizing machinery paths and irrigation scheduling [5], [1], [4].

2.2 Evolutionary Algorithms

Evolutionary algorithms (EAs) simulate evolutionary processes such as natural selection, reproduction, and genetic variation. Genetic Algorithms (GAs), the archetype, encode candidate solutions as chromosomes and evolve populations through crossover, mutation, and selection operators. Differential Evolution (DE) refines this paradigm by employing vector differences to perturb candidate solutions.

Cuckoo Search, inspired by brood parasitism in some cuckoo species, uses Lévy flights to perform global random walks and enhance exploration. These algorithms are particularly adept at handling multi-objective optimization problems, thanks to their population-based search, facilitating simultaneous exploration of diverse Pareto-optimal solutions.

EAs excel in problems where explicit gradient information is unavailable or unreliable, offering global search capabilities and adaptability to a wide range of problem formulations. Their modular design allows integration with other heuristics and problem-specific operators, enhancing efficiency in complex landscapes [4], [1], [5].

2.3 Other Bio-Inspired and Hybrid Approaches

Beyond established swarm and evolutionary algorithms, a growing class of bio-inspired metaheuristics draws from less conventional natural behaviors. The Jellyfish Search Optimizer (JSO), inspired by jellyfish's food-finding and movement patterns, represents such an emergent method combining population-based search with unique movement and influence mechanisms.

The Flower Pollination Algorithm (FPA), simulating pollination patterns in flowering plants, presents multi-objective capabilities with global and local search mechanisms. Increasingly, hybrid metaheuristics combine the strengths of multiple algorithms to handle problem-specific needs, multi-objective scenarios, and constraints efficiently.

Recent research trends incorporate artificial intelligence techniques with bio-inspired algorithms to enhance adaptability, convergence speed, and solution accuracy. These include hybridization with machine learning models, adaptive parameter tuning, and embedding intelligent agents for algorithm control. Such advances point towards flexible, customizable optimization frameworks applicable to diverse and dynamically changing problem domains [3], [4], [1].

3. ALGORITHMIC MECHANISMS AND THEORETICAL FOUNDATIONS

3.1 Population-Based Search Strategies

Core to nature-inspired algorithms is their reliance on population-based search strategies, where multiple candidate solutions evolve simultaneously. This feature facilitates a balance between exploration (searching new areas) and exploitation (refining current solutions). The tradeoff is critical; excessive exploration slows convergence, while premature exploitation risks local optima entrapment.

Maintaining population diversity through randomized operators and controlled parameter adjustments preserves the exploratory capabilities of the algorithm. Adaptive mechanisms modulate parameters such as mutation rates or inertia weights in real-time to sustain effective search dynamics and convergence stability.

Analyses of convergence behavior reveal that population-based methods benefit from stochastic dynamics and parallel search paths, improving robustness. Algorithm stability is further influenced by operator design and adaptation rules, which must be crafted to suit specific problem characteristics [2], [3], [1].

3.2 Use of Nature-Inspired Operators

Algorithms employ specialized operators reflecting natural phenomena to generate new candidate solutions. In evolutionary algorithms, classical operators include mutation, crossover, and selection, mimicking biological variation and survival of the fittest. Mutation introduces diversity, crossover combines traits, and selection favors superior individuals.

Swarm intelligence techniques often utilize communication and environmental interaction, such as pheromone updates in ACO, representing indirect cooperation mechanisms. PSO incorporates velocity and position updates influenced by personal and social best experiences to guide particles.

Emerging metaheuristics like JSO introduce unique operators based on jellyfish movement, combining ocean currents' uniform movement and swarm behavior influenced by food concentration. These novel operators enhance both global search and local exploitation phases, contributing to improved solution quality and convergence speed.

Such operators form the algorithmic backbone, and their careful design influences the efficiency, adaptability, and scalability of the metaheuristic frameworks [4], [5], [3].

3.3 Hybridization and Algorithm Modification

Hybrid metaheuristics combine complementary optimization strategies to leverage their individual strengths and mitigate weaknesses. For instance, merging evolutionary algorithms with swarm intelligence methods can yield algorithms capable of efficient global exploration and rapid local convergence.

Hybridization often addresses constraint handling and multi-objective optimization challenges by integrating specialized operators or adapting fitness evaluation mechanisms. Research demonstrates that hybrid algorithms outperform single-method approaches, especially in complex, multi-constraint environments.

Modifications include adaptive parameter control, problem-specific operator design, and integration with artificial intelligence models like neural networks or reinforcement learning. These enhancements facilitate better performance in terms of convergence speed, solution quality, and computational efficiency, underpinning future research directions [2], [3], [4].

4. IMPLEMENTATION ASPECTS AND PROGRAMMING ENVIRONMENTS

4.1 Programming Languages and Tools

Implementation of nature-inspired algorithms heavily favors flexible and high-level computational environments, with MATLAB emerging as a predominant choice among researchers. MATLAB's extensive toolboxes, visualization capabilities, and ease of prototyping make it ideal for algorithm development, experimentation, and benchmarking.

Besides MATLAB, languages such as Python, Java, and C++ are widely used, particularly when performance and scalability are critical. Python benefits from extensive libraries and frameworks supporting scientific computing and machine learning, facilitating hybrid algorithm development.

Libraries such as DEAP (Distributed Evolutionary Algorithms in Python) and frameworks for swarm intelligence provide reusable components, promoting reproducibility and accelerating development. The choice of language and tools often depends on application context, performance requirements, and integration needs [4], [1], [2].

4.2 Algorithm Parameter Setting and Adaptability

Parameter tuning critically influences the success of nature-inspired algorithms, affecting convergence, exploration balance, and robustness. Adaptability—an algorithm's capacity to adjust parameters dynamically in response to the search state—is increasingly recognized as a pivotal performance criterion.

Strategies include self-adaptation, where parameters evolve alongside solutions, and feedback-based adjustment that relies on real-time performance metrics. This adaptability enhances algorithm resilience to problem heterogeneity and reduces the need for manual parameter setting.

Effective parameter control translates directly to improved real-world applicability, especially in dynamic environments, where the optimization landscape may shift over time. Research efforts focus on formalizing adaptability assessments and embedding robust self-tuning mechanisms [4], [2], [3].

4.3 Integration Challenges and Security Considerations

Integrating nature-inspired algorithms into complex systems such as the Internet of Things (IoT) and cyber-physical systems presents challenges pertaining to heterogeneity, interoperability, and real-time constraints. The dynamic nature of such systems complicates algorithm deployment and necessitates robust communication and synchronization protocols.

Security concerns, including data integrity and privacy, are critical in domains like healthcare and smart agriculture. The risk of cyber-attacks and vulnerabilities in IoT infrastructures must be addressed to ensure reliable and trustworthy algorithmic deployment.

Furthermore, the current lack of standardized evaluation metrics impedes comparative assessments and benchmarking, making it difficult to gauge algorithm effectiveness consistently. These challenges underscore the need for developing secure, interoperable frameworks with standardized protocols for nature-inspired algorithm integration [4], [5].

5. APPLICATION IN INTERNET OF THINGS (IOT) BASED HEALTHCARE

5.1 Role of Nature-Inspired Algorithms in IoT Healthcare Systems

In the healthcare sector, IoT systems generate vast volumes of heterogeneous data via interconnected sensors and devices. Nature-inspired algorithms contribute to optimizing sensor network configuration, efficient data processing, anomaly detection, and predictive analytics, thereby enhancing responsiveness and service quality.

These algorithms enable advanced resource allocation, fault tolerance, and adaptability to changing conditions, essential for real-time monitoring and personalized healthcare services. Their capacity to handle multi-objective optimization is valuable in balancing energy consumption, delay, and accuracy within sensor networks.

By leveraging metaheuristics like genetic algorithms, particle swarm optimization, and ant colony optimization, IoT healthcare architectures realize enhanced performance in diagnostics, patient monitoring, and emergency response systems [4].

5.2 Integration Challenges and Security Concerns in Healthcare

Despite their potential, implementing nature-inspired algorithms in IoT healthcare ecosystems confronts integration difficulties. Heterogeneous device capabilities, communication protocols, and data formats complicate seamless algorithmic application. Additionally, healthcare data's sensitive nature raises significant privacy and security challenges.

Vulnerabilities to cyber-attacks threaten patient confidentiality and system integrity. Moreover, the absence of standardized benchmarking frameworks hinders consistent evaluation of algorithmic solutions' effectiveness, impairing trust and adoption.

Addressing these hurdles requires research into secure algorithm design, privacy-preserving optimization, and interoperable, standardized evaluation protocols tailored for healthcare IoT environments [4].

5.3 Future Directions and Research Gaps

Future research in this area should prioritize the development of hybrid methods specially tailored for the unique constraints of healthcare IoT systems. Security-aware optimization algorithms that inherently consider threat models and privacy preservation are imperative.

Furthermore, establishing standardized frameworks and benchmarks will facilitate rigorous evaluation and comparison of algorithmic approaches, encouraging wider adoption. Exploring these directions will contribute to more reliable, scalable, and secure IoT healthcare solutions [4].

6. AGRICULTURAL ENGINEERING APPLICATIONS

6.1 Predominant Bio-Inspired Algorithms in Agriculture

Agricultural applications have adopted several bio-inspired algorithms such as genetic algorithms, ant colony optimization, and particle swarm optimization to address domain-specific challenges. Applications include

machinery path optimization to reduce operational time and energy consumption, pest detection via optimized sensor placement, and irrigation scheduling through estimation of evapotranspiration rates.

By accurately modeling water requirements and optimizing irrigation, particle swarm optimization enhances resource efficiency, directly contributing to sustainable agriculture. These algorithms also support cost reduction and energy savings, amplifying their practical value in precision farming [5].

6.2 Limitations and Challenges in Agricultural Use

Despite promising results, adoption of hyper-heuristic algorithms in agriculture remains limited. No universal metaheuristic can perform multiple agricultural functions effectively; instead, specific algorithms address particular tasks, necessitating layered or integrated approaches.

Data integrity poses another challenge, as smart farming is increasingly exposed to cyber-security threats. Historic incidents of cyber-attacks underscore the need for robust protective measures to safeguard agricultural data and operations. Thus, algorithm design must also incorporate security considerations alongside optimization objectives [5].

6.3 Impact and Outcomes on Farm Management

Empirical outcomes demonstrate substantial benefits, including average fuel savings exceeding 6 million liters and corresponding economic gains between US\$ 734 and 851, attributed to algorithm-enabled GPS-guided machinery. The precision afforded by bio-inspired algorithms mitigates errors in pesticide, fertilizer application, and irrigation, translating to improved crop yields and sustainable farm management.

Such technological integration offers socio-economic advantages by reducing input costs and environmental impact, validating the adoption of biomimetic algorithms in modern agriculture [5].

7. OPTIMIZATION IN ENGINEERING AND INDUSTRIAL SYSTEMS

7.1 Addressing NP-Hard Combinatorial Problems

Combinatorial optimization challenges in engineering and industrial systems, such as vehicle routing, traveling salesman, and supply chain network design problems, are prototypical NP-hard problems requiring heuristic approaches. Metaheuristics excel in navigating the vast, discrete solution spaces characteristic of these problems.

Recent advances show that novel metaheuristics developed since 2000 outperform traditional methods, providing more efficient and scalable solutions. The flexibility of nature-inspired algorithms enables them to model realistic constraints and objectives, promoting practical deployment within industrial contexts [2], [1].

7.2 Parameter Handling and Performance Efficiency

Ease of parameter tuning remains essential for practical success. Metaheuristics featuring straightforward parameter sets and self-adaptive control facilitate easier application and reduce the computational overhead of trial-and-error calibration.

Hybrid algorithms enhance constraint management and multi-objective optimization, enabling tailored designs for industrial problems. Such algorithms are adapted to industry-specific needs, improving performance efficiency and robustness in operational environments [2], [1].

7.3 Recent Advances and Future Trends

Ongoing research explores algorithm modifications to accelerate convergence and improve solution quality. The integration of artificial intelligence and machine learning paves the way for autonomous and real-time optimization frameworks.

These trends point toward self-optimizing systems capable of adjusting strategy parameters dynamically based on historical performance and environmental feedback, promising significant advances in industrial optimization practices [2], [3].

8. EMERGING METAHEURISTICS: CASE STUDY OF JELLYFISH SEARCH OPTIMIZER

8.1 Biological Inspiration and Algorithm Framework

The Jellyfish Search Optimizer (JSO) is a bio-inspired metaheuristic developed based on the foraging and movement behavior of jellyfish in oceanic environments. It incorporates uniform movement influenced by ocean currents and active movement guided by the concentration of food sources, offering a novel framework for balancing exploration and exploitation.

JSO has demonstrated superior performance compared to classical gradient-based and some established metaheuristics in diverse benchmark functions. Its population-based approach exploits biological insights to maintain diversity and convergence stability, making it effective for solving complex engineering optimization problems [3].

8.2 Variants and Hybridizations of JSO

Several variants of JSO have been proposed to enhance its convergence speed and solution quality. These include modified operators, adaptive parameter schemes, and hybridizations integrating complementary artificial intelligence techniques such as neural networks or fuzzy logic.

Hybrid JSO algorithms expand the scope of applicability, tailoring the method to specific problem types and constraints while maintaining robustness. Research continues to refine these modifications to improve algorithm efficiency and real-world suitability [3].

8.3 Applications and Performance Evaluation

JSO has been applied successfully across various benchmark problems and real-world scenarios, showcasing strong robustness and adaptability. Evaluations highlight its ability to maintain solution quality in multi-objective and constrained optimization.

The systematic study of JSO and its variants provides a foundation for future research focused on developing superior bio-inspired optimization algorithms by leveraging add-on intelligent agents and further understanding of jellyfish-inspired mechanisms [3].

9. APPLICATIONS IN MICROELECTRONICS AND NANOPHOTONICS

9.1 Optimization Challenges in Microelectronics Design

Optimization in microelectronics, including circuit design, entails handling complex multi-parameter problems with stringent constraints related to performance, energy consumption, and manufacturing limitations. Similarly, nanophotonic structure design, such as photonic crystals and metamaterials, involves intricate, high-dimensional parameter spaces.

Bio-inspired algorithms address these challenges by enabling efficient exploration of multi-dimensional, non-linear search spaces, essential for inverse design problems in this domain [1].

9.2 Algorithmic Approaches and Classification in Micro/Nano Domains

Certain bio-inspired methods, including evolutionary strategies and swarm intelligence variants, demonstrate particular effectiveness in photonics and plasmonics applications due to their capability to approximate complex physical interactions and optimize non-convex functions.

Novel trends focus on scaling these algorithms to accommodate the precision and complexity required by nanostructure designs, often involving hybrid approaches and domain-specific heuristics to enhance convergence and solution accuracy [1].

9.3 Future Research and Cross-Disciplinary Opportunities

Bridging computational optimization with physical device design represents a fertile area for interdisciplinary research. Increasing automation of the design process—mediated by biomimetic algorithms—promises accelerated innovation cycles.

Moreover, emerging technologies like quantum computing might integrate with bio-inspired methods, opening new frontiers in optimization capabilities. Such cross-disciplinary approaches offer promising avenues for future exploration [1].

10. CRITICAL PERSPECTIVES AND FUTURE RESEARCH DIRECTIONS

10.1 Addressing Algorithmic Integration and Standardization

A critical challenge lies in establishing standardized evaluation metrics and protocols to objectively assess algorithm performance across varied application domains. Without standardized benchmarks, comparing efficacy and generalizability remains difficult.

Real-world implementation exposes integration challenges involving interoperability, adaptability, and security. Future research must prioritize these aspects to bridge the gap between theoretical advances and practical deployment, ensuring secure, reliable, and scalable use of nature-inspired algorithms [4], [5].

10.2 Advances in Hybrid and Multi-Objective Optimization

The development of hybrid and multi-objective metaheuristics continues to show promise in managing conflicting objectives and real-time constraints inherent in complex systems. Successful hybridizations exemplify how combining algorithmic paradigms can yield versatile optimization tools tailored to diverse scenarios.

Exploration of new hybridization strategies and improved constraint handling will enhance the effectiveness and applicability of nature-inspired algorithms in challenging domains [2], [3], [4].

10.3 Leveraging Emerging Technologies and Interdisciplinary Research

Integration of nature-inspired algorithms with AI, IoT, and cyber-physical systems expands their application landscape, particularly within healthcare, agriculture, and industrial automation. These interdisciplinary approaches catalyze the development of adaptive, intelligent optimization frameworks responsive to dynamic environments.

Moreover, investigating previously unexplored biological behaviors as inspiration for new algorithmic designs holds the potential to enrich the metaheuristic toolkit and address increasingly complex problems [4], [3], [1].

In summary, nature-inspired computational algorithms constitute a versatile and rapidly evolving field, offering robust solutions to complex optimization problems across multiple scientific and engineering domains. While foundational techniques such as genetic algorithms and particle swarm optimization continue to underpin much research, emerging methods like the Jellyfish Search Optimizer and novel hybridizations demonstrate the vitality and expanding horizon of the field. Addressing challenges in integration, standardization, and security, especially in emergent application areas such as IoT-based healthcare, will further enhance their practical impact and drive future innovation.

REFERENCES

- [1]. Z. Jaki, S. Devi, O. Jaki, K. GUHA, "A Comprehensive Review of Bio-Inspired Optimization Algorithms Including Applications in Microelectronics and Nanophotonics," *Biomimetics*, 2023. <https://doi.org/10.3390/biomimetics8030278>
- [2]. M. A. Rahman, R. Sokkalingam, M. Othman, K. Biswas, L. Abdullah, E. A. Kadir, "Nature-Inspired Metaheuristic Techniques for Combinatorial Optimization Problems: Overview and Recent Advances," *Mathematics*, 2021. <https://doi.org/10.3390/math9202633>
- [3]. J. Chou, A. Molla, "Recent advances in use of bio-inspired jellyfish search algorithm for solving optimization problems," *Scientific Reports*, 2022. <https://doi.org/10.1038/s41598-022-23121-z>
- [4]. Z. Amiri, A. Heidari, M. Zavvar, N. J. Navimipour, M. Esmailpour, "The applications of natureinspired algorithms in Internet of Thingsbased healthcare service: A systematic literature review," *Transactions on Emerging Telecommunications Technologies*, 2024. <https://doi.org/10.1002/ett.4969>

- [5]. C. Maraveas, P. G. Asteris, K. Arvanitis, T. Bartzanas, D. Loukatos, "Application of Bio and Nature-Inspired Algorithms in Agricultural Engineering," Archives of Computational Methods in Engineering, 2022. <https://doi.org/10.1007/s11831-022-09857-x>