A Comparative Evaluation of Meta-heuristic Techniques for AI Optimization

Dr. Kamaljeet Singh[1]*, Disha Rani[2], Rahul Punj[3], Sarabjit Kaur[4]

1 Assistant Professor, School of Computer Application, Lovely Professional university Jalandhar (Punjab), India.
Kamaljeet.sbbs@gmail.com
2 Assistant Professor, School of Computer science, Lovely Professional university Jalandhar (Punjab), India.
3 Assistant Professor, School of Computer science, Lovely Professional university Jalandhar (Punjab), India.
4 Assistant Professor, Department of Computer science &Engg, Lyallpur Khalsa College Technical campus Jalandhar (Punjab), India.

Abstract:

The goal of the fast developing multidisciplinary research of AI is to create intelligent computers that are able to carrying out tasks that traditionally need intelligence from humans. Since there is a lot of data available, increased computational power, and breakthroughs in machine learning algorithms, AI has become ubiquitous, finding applications in diverse fields such as healthcare, finance, transportation, and entertainment. Optimization techniques have also played a crucial role in solving complex problems in various domains, including manufacturing, healthcare, finance, and transportation, by improving decision-making processes, increasing efficiency, and reducing costs. This paper provides an overview of optimization techniques used in AI, including deep learning, evolutionary algorithms, and metaheuristics, and discusses the challenges and ethical implications associated with their use. Specifically, the paper focuses on metaheuristic optimization techniques and their applications in AI, highlighting their strengths & weaknesses, and providing a comparative analysis. The aim of this work is to present a comprehensive interpretation of metaheuristic optimization techniques & their role in advancing AI research.

Keywords: Artificial Intelligence, Optimization, Meta-heuristic, Deep Learning, Reinforcement Learning.

1. INTRODUCTION

The capacity of machines to carry out tasks that typically call for human intelligence, including as sensing, thinking, learning, or DM, is known as AI[1]. AI has the possible to transform the way suggested technique complex problems & improve our lives. By examining the search space or assessing the quality of potential remedies, optimization methods are employed to identify the optimal solution to an issue. AI and optimization techniques have been used in various fields, such as manufacturing, healthcare, finance, & transportation [2], to enhance DM processes, increase efficiency, and reduce costs.

1.2. Use of AI in Optimization Algorithms

AI has made a significant impact on optimization algorithms. AI approaches, including ML & DL, are used to develop more efficient and effective optimization algorithms [3]. These techniques enable optimization algorithms to train from information & adjust their parameters to enhance their production.

1.2.1. Machine Learning

It is a subfield of AI that concentrates on growing approaches that could train from information. In optimization, ML approaches can be utilized to estimate the behavior of a system and optimize it accordingly. For example, in finance, ML approaches could be utilized to estimate stock prices & optimize investment portfolios.

1.2.2. Deep Learning

ANN with multiple levels of nodes are trained as part of DL, a type of ML. The nodes in each layer process the input data and pass it on to the next layer. Deep learning has been utilize to fix several issues, such as image and video identification, speech recognition, & NLP.

CNNs are a type of deep learning architecture that is used for image and video recognition. CNNs consist of multiple layers of convolutional filters that extract features from the input information. RNNs are another kind of DL framework that is used for speech recognition and natural language processing. RNNs use a feedback loop to process the input data and generate an output.

1.2.3. Natural Language Processing

It is another AI technique that is used in optimization algorithms. NLP is the process of analyzing human language and extracting meaning from it. In optimization, NLP can be used to analyze large set of information & recognize designs that can be used to optimize a system. For instance, in marketing, NLP could be used to examine customer feedback and optimize marketing campaigns accordingly.

1.3. Optimization Techniques

Optimization techniques [4] involve the development of algorithms that can find the best solution to a problem within a amount of limitations. Optimization techniques could be classified into 2 categories: deterministic & stochastic. Deterministic optimization approaches, like linear programming, use mathematical models to select the best remedy to a issue. Lin et al.[5] explained new developments in deterministic techniques for tackling mixed-integer nonlinear programming issues as well as signomial programming issues. To demonstrate the value of the optimization approaches, several of significant uses in management and engineering are also examined. Stochastic optimization techniques, like genetic approaches and simulated annealing, use randomness to search for the best solution to a issue. Chung et al.[6] Created a model stochastic optimization issue for the scenario of several scattered mobile sensors monitoring one or more interesting items. The incorporation of such exploration stage, with the use of screening experimental approaches that offer local approximation to the reaction surface, enhances the stochastic optimization method, as demonstrated through simulations.

Heuristics & metaheuristics are two different categories of approximate methods. The heuristic methods have two major drawbacks:

• Efficiency decrease in real-world applications involving complicated issues;
• High probability of becoming caught in local optima.

To solve the issues with heuristic computations, metaheuristic methods have been developed. Metaheuristic techniques may be used to solve a wide variety of optimization issues & are actually approximate optimization techniques with particular methods for leaving local optima.

A complete hierarchical diagram of optimization algorithms presented in fig. 1.

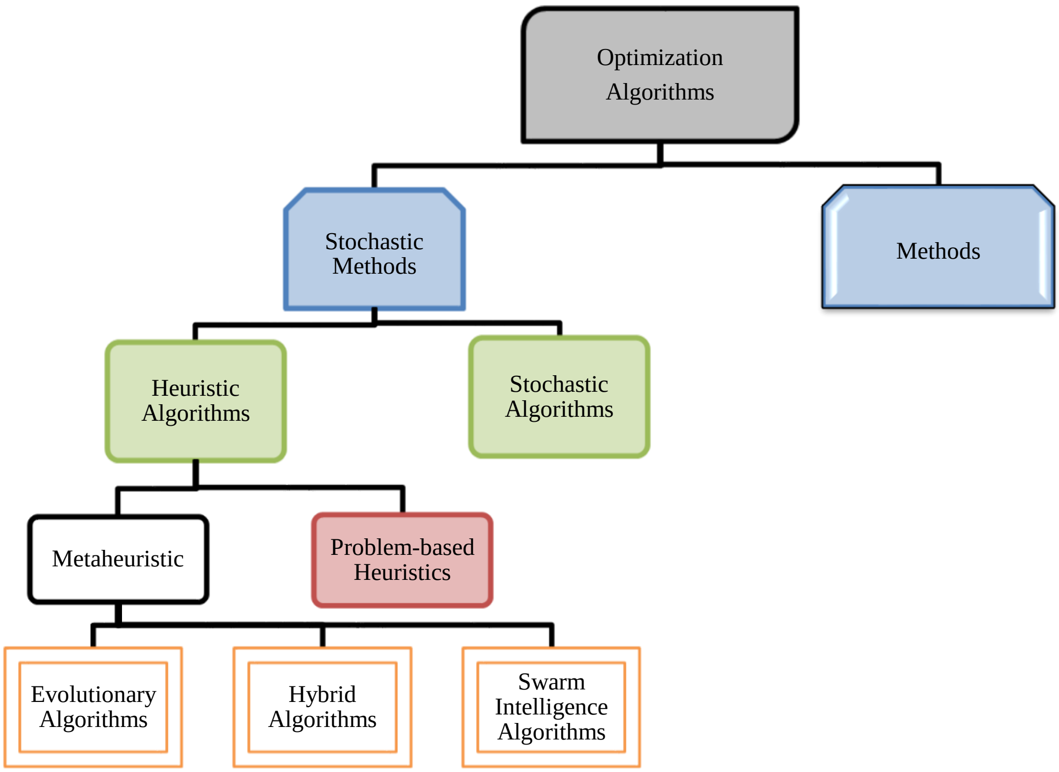

Fig. 1. Hierarchy of Optimization Techniques in AI

1.4. Applications of AI & Optimization Algorithms

The use of AI & optimization approaches has resulted in significant improvements in many fields. Here are some examples [7]:

- *Engineering:* Optimization algorithms are used to design aircraft, cars, and buildings that are more efficient, safer, and cost-effective. AI techniques such as ML & DL are utilize to optimize the design method & improve the performance of these systems.
- *Finance:* Optimization algorithms are used to optimize investment portfolios and risk management strategies. AI approaches like ML & DL are used to predict stock prices and optimize investment decisions.
- *Healthcare:* Optimization algorithms are used to design treatment plans that are personalized to individual patients. AI approaches like ML & DL are used to analyze patient data and optimize treatment plans accordingly.
- *Marketing:* Optimization algorithms are used to optimize marketing campaigns and improve customer engagement. AI techniques such as NLP are used to analyze customer feedback and optimize marketing strategies accordingly.
- *Manufacturing:* AI and optimization approaches have been utilize extensively in manufacturing to automate production processes and reduce costs. One example is the use of AI algorithms to optimize production scheduling, which involves determining the sequence of tasks to be performed on a production line. Another example is the use of optimization techniques to minimize waste and reduce energy consumption in manufacturing processes.
- *Transportation:* AI and optimization approaches have been utilize in transportation to automate logistics and reduce costs. One example is the use of AI algorithms to optimize routes for delivery trucks. Another example is the use of optimization techniques to minimize fuel consumption and reduce emissions for transportation vehicles.

1.4. Challenges

Although AI and optimization techniques have several advantages, there are also challenges and ethical implications connected with their use. One challenge is the lack of transparency in AI algorithms. In some cases, AI algorithms may be making decisions that are difficult to understand or justify [8]. Another challenge is the potential for bias in AI approaches. If the training information used to develop the AI approach is biased, the approach may make biased decisions.

Ethical implications associated with the use of AI and optimization techniques include privacy concerns and the potential for job displacement. As AI and optimization techniques continue to advance, it is significant to examine the ethical implications of their use and develop policies to address these concerns [9].

The paper is structured into 5 sections. Section 1 provides an introduction to Artificial Intelligence (AI) and optimization techniques. Section 2 presents a literature survey on the use of optimization techniques in AI, highlighting the most relevant works and their contributions. Section 3 provides an in-depth analysis of metaheuristic optimization techniques, including their principles, advantages, and disadvantages. This section also provides a comparative analysis of different metaheuristic algorithms, such as SA, TS, GA, PSO, & ACO. Section 4 discusses the applications and challenges of using metaheuristic techniques in AI. This section focuses on real-world applications of metaheuristic algorithms in several domains, like manufacturing, healthcare, finance, & transportation, and also discusses the challenges and ethical implications associated with their use. Finally, Section 5 presents the conclusion of the paper, summarizing the main findings & contributions of the study and highlighting future research directions.

2. LITERATURE SURVEY

Sukhpreet et al. [10] A thorough search was conducted, and 173 papers from many research the form of databases, including Scopus, Web of Science, PubMed, PsycINFO, and others, were found to have significant effects on the use of metaheuristic methods to diagnose the disorders. The main objective is to highlight the researchers' contributions by showcasing their approach to disease prediction using the aforementioned metaheuristic methodologies. Later, to aid the researchers in selecting the proper field and methods for disease prediction, their work was also contrasted & analyzed using accuracy, precision, F1 score, error rate, sensitivity, or specificity, among other metrics. By a margin of 99.83%, moth fame optimization has attained the greatest rate for microarray gene cancer diagnosis.

Biedrzycki et al.[11] Find two optimisation problems that have been solved in relation with building adversarial examples and training DL models that are This serves as the basis for proposed examination of popular optimisation techniques within the DL community. In addition, we describe outcomes from research on black-box optimization and metaheuristics. Authors concentrated on popular optimizers that are effective in solving RN tasks and produce positive results on benchmarks and in contests. Finally, examined the study on combining DL models with metaheuristic optimization techniques.

Ezugwu et al.[12] provided a current overview of the most important nature-inspired metaheuristic methods that have been used to address automatic clustering issues. The firefly method proved to be more suitable than other modern algorithms for better clustering of both high & low dimensional information items, based to the extensive findings from experiments, comparisons, and statistical significance. Additionally, an experimental research shows that the 3 suggested hybrid approaches outperform the conventional state-of-the-art approaches in identifying useful clustering remedies for the issue at hand.

G. Suresh et al.[13] AGLDR-WOADL is a method for Automated Groundnut Leaf Disease Recognition utilizing WOA with DL. To find the sick areas of the image, threshold-based segmentation is primarily used. The technique for extracting big features from NASNet is then used. Finally, to identify various plant diseases, the WOA with LSTM approach is used. A broad spectrum of simulations was run to show the enhanced performance of the AGLDR-WOADL approach. The thorough comparative analysis showed that the AGLDR-WOADL strategy produced better results than other currently used approaches, with a greater accuracy of 99.63%.

T. Kumar et al.[14] uses the MRFO-DLA to create a computerized system for classifying chest X-ray images. The MRFO-DLA technique that is being described focuses primarily on the identification and categorization of illnesses utilizing CXRs. The MRFO-DLA technique that has been disclosed achieves this by using a BF method during the image preprocessing phase. The MRFO-DLA model then extracts features using a neural architecture search network (NASNet). The MRFO with AE design is used for CXR classification at the very end. A number of simulations were run, and the results were examined from various angles, to show the improved performance of the MRFO-DLA approach. The results of the simulation verified the improvements of the MRFO-DLA strategy in comparison to more contemporary techniques in terms of several measures.

P. Sudha et al.[15] developed the LSODL-BFPRR methodology. The SBiGRU method was used in the previously mentioned LSODL-BFPRR method to classify return rates. The LSO technique is used to adjust the hyper parameters depend on the SBiGRU method. The LSODL-BFPRR strategy uses the Ethereum (ETH) return rate as its aim. A series of computations are used to test the experimental outcomes of the LSODL-BFPRR method, as findings show that this method predicts outcomes more accurately than others.

J. Anitha et al.[16] created a method called HPSO-DLSD, which stands for HPSO with DL Driven Sarcasm Identification. The primary focus of the demonstrated HPSO-DLSD approach is the recognition of sarcasm on social media. The first phase of data preprocessing is completed in the illustrated HPSO-DLSD method. The sparse SAE designs are used to identify & categorize sarcasm, while the HPSO technique can improve detection performance. The benchmark dataset may be used to test the experimental results of the HPSO-DLSD approach, and the outcomes highlighted its improvements over other existing methods.

Marium et al.[17] Fundamentally an image processing strategy is contrasted to the cutting-edge deep learning algorithms in this research to identify a tumour in the MRI images of the brain. Simple methods using methods for image improvement & morphological operations are also significantly more efficient in this regard. The simple system is broken down into four phases. The scan is first pre-processed to improve its quality. Second, image enhancement techniques are used to improve the image. Third, it is subjected to edge detection methodologies. The tumour area is located using image segmentation with morphological operators in step four. The outcomes are then contrasted with those of earlier deep learning methods. This work aims to demonstrate that more sophisticated DL approaches may produce superior outcomes and carry out numerous classifications of brain tumour identification in MRI images.

Lowrie et al.[18] established a structure for approaching the study of heuristic processes for resolving issues involving numerical optimization. 'Techniques employing testing for requirement & generation of Heuristics 2.0' (TEACHER 2.0) is a system for learning heuristic features. The method stands out because it incorporates several methods of learning into a single, cohesive framework. Given that it enables the creation of heuristics depend on a combination of learning approaches or tactics, it has the potential to be a potent learning system. A case where TEACHER 2.0 trains a novel heuristic that is better than the common heuristic for that issue area serves as an illustration of the system's utility.

Table 1: Copmparative Analysis of Various Metaheuritics techniques in different Fields

References	Objective	Technology used	Dataset/Parameters	Conclusion
Sukhpreet et al.[10]	Predict diseases	Metaheuristic techniques like CS,FA.MFO,WOA.	Accuracy, precision, F1 score, error rate, sensitivity, specificity	By a margin of 99.83%, moth fame optimization has attained the greatest rate for

				microarray gene cancer diagnosis.
G. Suresh et al.[13]	Groundnut Leaf Disease Recognition	WOA	Accuracy	The AGLDR-WOADL methodology has superior results to other current techniques, with a higher accuracy of 99.63%.
J. Anitha et al.[16]	Sarcasm Detection	Hybrid PSO with DL	Benchmark dataset	Benchmark datasets could be used to test the HPSO-DLSD method, and the results highlighted its advantages over other existing methods.
P. Sudha et al.[15]	Predictive Model on Blockchain Financial Product Return Rates	Lion Swarm Optimization with DL, stacked bidirectional gated recurrent unit	-	Findings showed that the performance was superior.
T. Kumar et al.[14]	Automated Chest X-Ray Image Classification	Manta Ray Optimization with DL	-	The MRFO-DLA technique was improved as a result of the simulation results.
Marium et al.[17]	Finding a tumour in the brain's MRI imaging.	Strategies for improving images & morphological processes	-	Better findings and numerous classifications for the identification of brain tumours in MRI images.

3. METAHEURISTIC OPTIMIZATION TECHNIQUES IN AI

Metaheuristic optimization techniques are a class of computational approaches that have been developed to fix complicated optimization issues [19]. These algorithms are designed to work without demanding any prior knowledge of the problem domain, and are generally able to find near-optimal answers in a reasonable set of time. They are particularly useful in the field of AI, where many problems are inherently difficult to solve using traditional optimization techniques. These problems may involve a large number of variables, non-linear relationships, and noisy data. Examples of such problems include feature selection, parameter tuning, image detection, NLP,& game playing.

The concepts of evolution, SI, and various other natural occurrences form the foundation of met heuristic optimization approaches, which draw their inspiration from nature [20]. Unlike traditional optimization techniques, which rely on mathematical models, metaheuristics use heuristic search methods to explore the search space & find the good answer. SA, TS, &

ACO are few instances of metaheuristics. These techniques have been utilize to fix optimization issues in various areas, like logistics, finance, and engineering.

3.1. General Block Diagram of a Metaheuristic Optimization Approach

This section discusses block diagram that illustrates the general structure of a metaheuristic optimization algorithm, as shown in fig. 2. The block diagram illustrates the common structure of metaheuristic optimization algorithms. At the beginning of the algorithm, an initial solution(s) is created randomly or using some heuristics. Then, the fitness of the initial solution(s) is evaluated using an objective function. The termination criteria are also set based on some predefined conditions [21], [22]. The main loop of the algorithm consists of four steps: solution generation, solution evaluation, solution acceptance, and update. Utilizing various stochastic managers, the present solution(s) are perturbed in the solution creation stage to produce novel solutions. In the solution evaluation step, the fitness of the new solution(s) analyzed an using the objective function. In the solution acceptance step, the new solution(s) is accepted or rejected based on some acceptance criteria. In the update step, the current solution(s) is updated based on the accepted new solution(s). The approach terminates when the termination criteria are met, and the best solution found during the optimization process is returned.

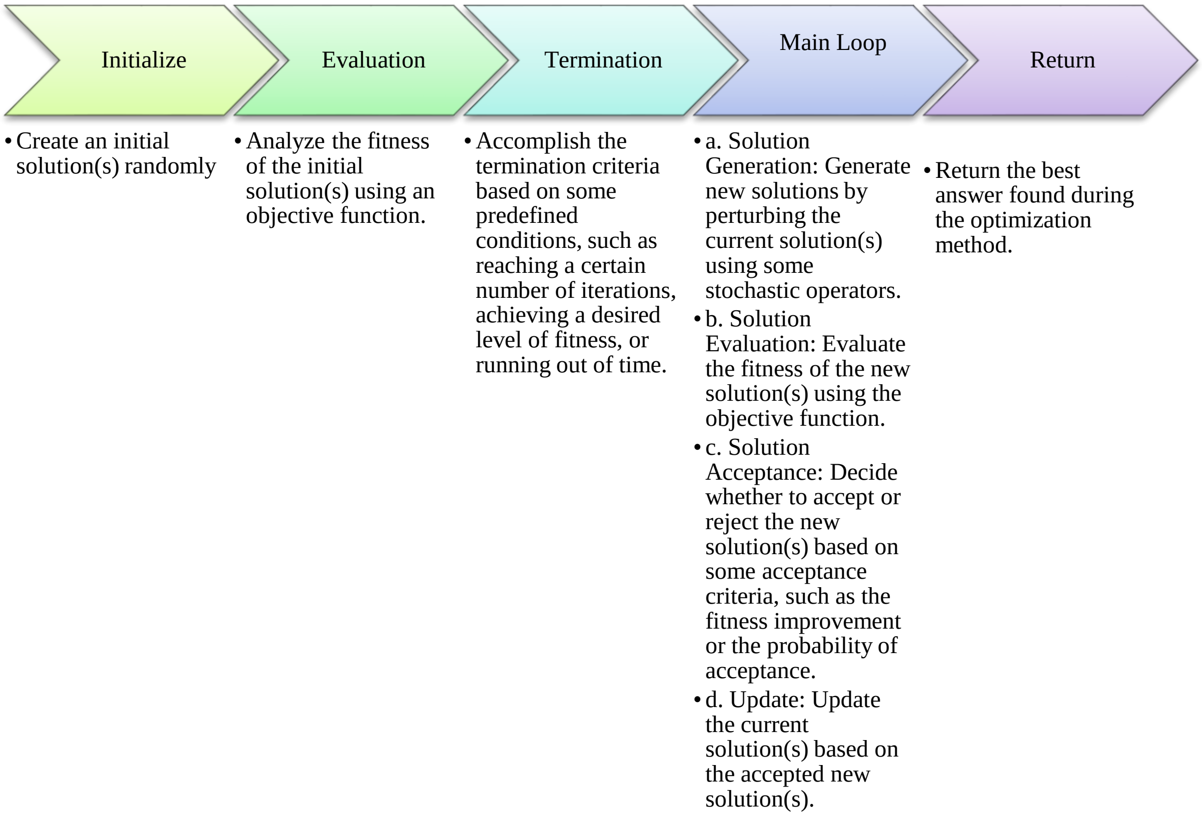

Fig. 2. A General Structure of a Metaheuristic Optimization Algorithm

3.2. Comparative Analysis of Metaheuristic Optimization Algorithms

This section will provide a comparative analysis of some of the most popular metaheuristic optimization algorithms. These algorithms are allow of selecting near-optimal answers in a reasonable amount of time without requiring any prior knowledge of the problem domain [23]. However, different metaheuristic algorithms have different strengths and weaknesses, and the choice of approach focuses on the nature of the issue.

3.2.1. Swarm Intelligence

It is a field of AI that concentrates on the collective behavior of groups of agents, such as ants, bees, birds, and fish [24]. The basic idea behind swarm intelligence is that groups of agents can collectively perform tasks that are beyond the capabilities of individual agents. Swarm intelligence algorithms are based on the principles of self-organization, decentralization, and local interactions.

PSO

It is one of the most largely utilize swarm intelligence approaches in AI. The behaviour of a cluster of atoms in a search space serves as the basis for the population-based optimization technique known as PSO. The basic idea behind PSO is that particles move in the search space according to their own velocity & the best location they have noted so far. The approach updates the velocity & position of each particle in every iteration; depend on its own experience & the experience of the best particle in the swarm. Y.V.R. Naga Pawan et al.[25] introduced 2 novel PSO models that employ LSTM and CNN to forecast the weight of inertia when moving the swarm to improve swarm performance. The five most popular benchmark functions are employed in experiments with swarm sizes of 50, 75, & 100 with dimensions 10, 15, and 25. The outcomes demonstrated that the novel designs outperform the current constant, random, and linearly decreasing inertia weight PSO models in terms of performance.

ACO

ACO is another SI algorithm, associated by the foraging behavior of ants. By imitating the behaviour of ants seeking the shortest route between their colony and a food supply, algorithmic approaches to ACO are employed to resolve optimization issues like the travelling salesman problem.

In ACO algorithms, an artificial ant is represented as a solution to the optimization issue. The ants submit pheromones on the path they travel, & the set of pheromone deposited is relative to the amount of the solution. As more ants travel on a path, the amount of pheromone on that path increases, making it more attractive for other ants. This leads to a self-reinforcing positive feedback loop, where the pheromone trails converge towards the best solution.

ACO algorithms have been successfully applied to various optimization issues, like vehicle routing, scheduling, network optimization. They are particularly useful for problems with a large search space, non-linear relationships, and noisy data. Tambouratzis et al.[26] An automated procedure that utilizes a set of training data is used to apply the ACO metaheuristic to the goal of creating close to optimum system weights. The results of the studies show that the segmentation quality produced by ACO is comparable to, or in some instances significantly greater than, that produced by individually optimized weights.

3.2.2. Evolutionary Appraoches

The concepts of development or genetics serve as the foundation for the class of metaheuristic optimization algorithms known as evolutionary approaches. These approaches are based on the idea of natural selection, which involves the survival of the fittest individuals in a population. Evolutionary approaches are certainly useful for fixing issues that contains a huge amount of parameters or where the fitness landscape is complex and multi-modal [27].

Genetic Algorithm

Genetic Algorithms (GA) are the most well-known evolutionary algorithms. GA [28] is a population-based optimization approach that uses genetic operators, like mutation, crossover, selection, to evolve a population of candidate solutions. The basic idea behind GA is to mimic the process of natural selection, where the fittest individuals are selected for reproduction. Kim et al.[29] bring forth a novel approach depend on genetic programming to locate the best optimisation methods or activation processes at the same time. Authors build a NN using the activation function and optimization method that the person represents in order to determine the fitness of one individual. The DL model discovered using proposed method surpasses traditional approaches with accuracy rates of 82.59% and 53.04% for the CIFAR-10 and CIFAR-100 data sets, respectively. Authors also examine the discovered activation function to support the utility of the suggested approach.

Differential Evolution

It is another evolutionary approach that is particularly useful for continuous optimization problems. DE is a population-based metaheuristic optimization approach used for solving nonlinear, non-differentiable, & non-convex optimization issues. It was suggested by Storn & Price in 1997. The basic idea of DE is to maintain a population of candidate solutions (vectors), with each vector representing a potential solution to the optimization issue. The algorithm operates by iteratively generating new candidate solutions through the application of three operators: mutation, crossover, and selection. DE has been implementing in many areas, such as power system optimization, parameter identification, image processing, and machine learning. Its versatility and effectiveness make it a valuable tool in solving complex optimization problems.

DE has several advantages over other optimization techniques, including its ability to handle noisy and dynamic environments, and its fast convergence rate. However, DE has some limitations, such as its sensitivity to the selection of the mutation and crossover parameters, and its tendency to get stuck in local optima. Kumar et al.[30] provided a new differential evolution-based technique that takes use of the network's structural similarities to produce a better starting population and more precise community designation.

3.2.3. Hybrid Metaheuristic Optimization Techniques

Hybrid metaheuristic optimization techniques are combinations of different metaheuristic algorithms, or the integration of metaheuristic algorithms with other optimization techniques. The primary benefit of hybrid techniques is that they can merge the strengths of different algorithms and overcome their weaknesses. Some popular hybrid techniques in AI include GA with SA, ACO with PSO, and Genetic Programming with Neural Networks.

Table 2:Comparsion of Hybrid Metaheuristic Optimization Approaches

References	Objective	Technology /Algorithm	Dataset	Research Findings
Y.V.R. Naga Pawan et al.[25]	Estimate the inertia weight	PSO	-	The novel methods significantly outperform the constant, random, & linearly increasing inertia weight PSO designs, according to the outcomes.
Tambouratzis et al.[26]	Defining near-optimal system weights	ACO	Utilizing an ACO Metaheuristic to Optimize Automatic Word Segmentation for Ancient Greek	The segmentation quality obtained by ACO is comparable to, or in some instances, far better than that obtained by manually optimizing weights.
Kim et al[29]	Select the optimal activation functions & optimization approaches.	GA	CIFAR-10 and CIFAR-100 datasets	Our methodology yielded a DL model with 82.59% and 53.04%.
Kumar et al.[30]	Identification communities.	Differential evolution	Zachary Karate Club, American College Football	More accurate

4. Applications and Challenges of Metaheuristic Optimization Techniques in AI

Metaheuristic optimization techniques have found applications in various domains of AI, including machine learning, natural language processing, image recognition, and game playing. In machine learning, these techniques are often used for feature selection, parameter tuning, and model optimization. In NLP, they are utilizing for text classification and SA. In image recognition, they are used for object detection and tracking. In game playing, they are used for finding optimal strategies in games such as chess and Go.

Despite their usefulness, metaheuristic optimization techniques still face some issues. One of the major issues is the choice of appropriate parameters for the approach. The conductance of a metaheuristic approach depends heavily on the selection of appropriate parameters, such as the population size, mutation rate, and crossover rate. Another challenge is the balance among exploration & exploitation. Metaheuristic approaches need to balance among exploring the search space to find new solutions and exploiting the current solutions to improve the search performance.

5. CONCLUSION

In conclusion, metaheuristic optimization techniques have become an indispensable tool for solving complex optimization issues in the area of AI. This paper provides an overview of the most popular optimization approaches utilize in AI, including DL, evolutionary algorithms, and metaheuristics. Among these techniques, metaheuristic algorithms have been found to be particularly effective in fixing a huge range of optimization issues because of their ability to explore complex search spaces and find near-optimal solutions in a reasonable amount of time.

This paper has also presented a comparative evaluation of distinct metaheuristic algorithms, including SA, TS, GA, PSO & ACO. Furthermore, this paper has discussed the applications and challenges of using metaheuristic techniques in AI. The applications of metaheuristic algorithms are diverse, ranging from feature selection and parameter tuning to image recognition and game playing.

Future research in this area should focus on developing more efficient and effective metaheuristic algorithms, improving their scalability and robustness, and addressing the ethical concerns associated with their use.

REFERENCES

[1] Joiner, I. A. Artificial Intelligence. *In Elsevier eBooks,* pp. 1–22, 2018. https://doi.org/10.1016/b978-0-08-102253-5.00002-2

[2] Abduljabbar, Rusul; Dia, Hussein; Liyanage, Sohani; Bagloee, Saeed (2019). Applications of Artificial Intelligence in Transport: An Overview. *Sustainability*, 11(1), 189. doi:10.3390/su11010189

[3] Sarker, I. H. (2021). Machine Learning: Algorithms, Real-World Applications and Research Directions. *SN Computer Science*, 2(3). https://doi.org/10.1007/s42979-021-00592-x

[4] Gebhardt, V. (2022, September 23). Intro to Optimization - Towards Data Science. Medium. https://towardsdatascience.com/intro-to-optimization-f27ec87fbef1

[5]Lin, M.-H., Tsai, J.-F., & Yu, C.-S. (2012). A Review of Deterministic Optimization Methods in Engineering and Management. *Mathematical Problems in Engineering*, 1–15. doi:10.1155/2012/756023

[6] Chung, T. H., & Spall, J. C. (2015). Integrated stochastic optimization and statistical experimental design for multi-robot target tracking. *Winter Simulation Conference (WSC).*

[7] Koopialipoor, M., & Noorbakhsh, A. Applications of Artificial Intelligence Techniques in Optimizing Drilling. *In IntechOpen eBooks*, 2020. https://doi.org/10.5772/intechopen.85398

[8] Felzmann, H., Fosch-Villaronga, E., Lutz, C., & Tamò-Larrieux, A. (2020). Towards Transparency by Design for Artificial Intelligence. *Science and Engineering Ethics*, 26(6), 3333–3361. https://doi.org/10.1007/s11948-020-00276-4

[9] Naik, N., Tokas, T., Shetty, D. K., Swain, D., Shah, M., Paul, R., Aggarwal, K., Ibrahim, S., Patil, V., Smriti, K., Shetty, S., Rai, B. P., Chlosta, P., & Somani, B. K. (2022). Legal and Ethical Consideration in Artificial Intelligence in Healthcare: Who Takes Responsibility? Frontiers in Surgery, 9. https://doi.org/10.3389/fsurg.2022.862322

[10]Sukhpreet Kaur · Yogesh Kumar · Apeksha Koul · Sushil Kumar Kamboj, “A Systematic Review on Metaheuristic Optimization Techniques for Feature Selections in Disease Diagnosis: Open Issues and Challenges”, Archives of Computational Methods in Engineering (2023) 30:1863–1895

[11]Biedrzycki, R., Zawistowski, P., & Twardowski, B. (2019). *Deep Learning Optimization Tasks and Metaheuristic Methods. Fundamenta Informaticae, 168(2-4), 185–218.* doi:10.3233/fi-2019-1828

[12]Ezugwu, A. E. (2020). *Nature-inspired metaheuristic techniques for automatic clustering: a survey and performance study. SN Applied Sciences, 2(2).* doi:10.1007

[13]G. Suresh; K. Seetharaman, "Automated Groundnut Leaf Disease Recognition Using Whale Optimization Algorithm with Deep Learning Model", *International Conference on Augmented Intelligence and Sustainable Systems (ICAISS) .*

[14]T. Kumar; R. Ponnusamy, "Automated Chest X-Ray Image Classification using Manta Ray Optimization with Deep Learning Approach", *International Conference on Augmented Intelligence and Sustainable Systems (ICAISS) .*

[15]P. Sudha; J. Jegathesh Amalraj; M. Sivakumar, "Lion Swarm Optimization with Deep Learning Driven Predictive Model on Blockchain Financial Product Return Rates", *2023 Second International Conference on Electronics and Renewable Systems (ICEARS)*

[16]J. Anitha Josephine; Santosh Kumar Maharana; Md. Abul Ala Walid; Thulasimani T; "Hybrid Particle Swarm Optimization with Deep Learning Driven Sarcasm Detection on Social Media", 2022 *International Conference on Automation, Computing and Renewable Systems (ICACRS)*

[17]Marium Malik; Muhammad Arfan Jaffar; Muhammad Raza Naqvi, "Comparison of Brain Tumor Detection in MRI Images Using Straightforward Image Processing Techniques and Deep Learning Techniques", *2021 3rd International Congress on Human-Computer Interaction, Optimization and Robotic Applications (HORA) .*

[18] Lowrie, M., & Wah, B. (n.d.). Learning heuristic functions for numeric optimization problems. Proceedings COMPSAC 88: *The Twelfth Annual International Computer Software & Applications Conference.* doi:10.1109/cmpsac.1988.17214

[19]Yang, X. (2011). Metaheuristic Optimization. Scholarpedia, 6(8), 11472. https://doi.org/10.4249/scholarpedia.11472

[20] Chandrakant, K., & Chandrakant, K. (2022). Overview of Nature-Inspired Metaheuristic Algorithms | Baeldung on Computer Science. Baeldung on Computer Science. https://www.baeldung.com/cs/nature-inspired-algorithms

[21] Oftadeh, R., Mahjoob, M. J., & Shariatpanahi, M. (2010). A novel meta-heuristic optimization algorithm inspired by group hunting of animals: Hunting search. Computers & Mathematics With Applications, 60(7), 2087–2098. https://doi.org/10.1016/j.camwa.2010.07.049

[22] Sun, Q., Wu, H., & Petrosian, O. (2022). Optimal Power Allocation Based on Metaheuristic Algorithms in Wireless Network. Mathematics, 10(18), 3336. https://doi.org/10.3390/math10183336

[23] Kaur, S., Kumar, Y., Koul, A., & Kamboj, S. K. (2022). A Systematic Review on Metaheuristic Optimization Techniques for Feature Selections in Disease Diagnosis: Open Issues and Challenges. Archives of Computational Methods in Engineering, 30(3), 1863–1895. https://doi.org/10.1007/s11831-022-09853-1

[24] Corne, D., Reynolds, A., & Bonabeau, E. (2012). Swarm Intelligence. In Springer eBooks (pp. 1599–1622). https://doi.org/10.1007/978-3-540-92910-9_48

[25] Y.V.R. Naga Pawan, Kolla Bhanu Prakash, Subrata Chowdhury.(2022),"Particle swarm optimization performance improvement using deep learning techniques", *Multimedia Tools and Applications* ,volume 81, pages27949–27968 (2022)
[26] Tambouratzis, G. (2009). Using an Ant Colony Metaheuristic to Optimize Automatic Word Segmentation for Ancient Greek. IEEE Transactions on Evolutionary Computation, 13(4), 742–753.
[27] Albadr, M. a. A., Tiun, S., Ayob, M., & Al-Dhief, F. T. (2020). Genetic Algorithm Based on Natural Selection Theory for Optimization Problems. Symmetry, 12(11), 1758. https://doi.org/10.3390/sym12111758
[28] Katoch, S., Chauhan, S., & Kumar, V. (2021). A review on genetic algorithm: past, present, and future. Multimedia Tools and Applications, 80(5), 8091–8126. https://doi.org/10.1007/s11042-020-10139-6
[29] Kim, J.-Y., & Cho, S.-B. (2019). Evolutionary Optimization of Hyperparameters in Deep Learning Models. *IEEE Congress on Evolutionary Computation (CEC).* doi:10.1109/cec.2019.8790354
[30] Kumar, A., Gupta, V., Singh, G. K., Shakya, H. K., & Biswas, B. (2014). Improvisation of differential evolution for community detection. 2014 IEEE *International Conference on Computational Intelligence and Computing Research*.