Optimizing Skin Disease Diagnosis using Metaheuristic Algorithms: A Comparative Study

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ABSTRACT

Skin diseases, having a wide range of symptoms and appearances, has been putting stern challenge in the field of dermatology. However, early and accurate diagnosis are crucial factors in the field of dermatology to treat and manage skin conditions effectively. In deep demand, the study reveals the potential of metaheuristic algorithms for skin disease diagnosis and aims a comparison with traditional diagnostic techniques. A real-time dataset is collected including clinical information, medical images and histopathological data of several patients affected with different skin diseases. The test dataset has been reviewed to ensure its perfection and representation among several categories of diseases. Several metaheuristic algorithms are introduced like Particle Swarm Optimization (PSO), Genetic Algorithm (GA), Antlion Optimization (ALO) and Ant Colony Optimization (ACO) in this study. These algorithms are customized for skin disease diagnosis fulfilling all the requirements. To examine the performance of the proposed metaheuristic algorithms, a comparative analysis is conducted. Furthermore, certain performance metrics such as diagnostic accuracy and results of standard deviation, mean fitness score, best fitness score, and worst fitness score are calculated. The initial results of this study show that the metaheuristic algorithms have high potentials for effective diagnosing of skin diseases. The obtained results are not only delivering highest accuracy but computational speed is also improved. In addition, the conducted comparative analysis also indicates the variations in selecting different metaheuristic algorithms. The achieved results showed that the ALO algorithm has outperformed other algorithms with 93% accuracy level. While the ACO achived 90%, the GA has 89% and the PSO worked well with 88% accuracy.

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1. Iintroduction

Dermatological diseases are conditions that have an impact on our skin, mucus membranes, hair and nails. They can also include allergies, infections, cancerous tumors, skin diseases that are hereditary and inherited, as well as skin diseases that result from our environment or lifestyle. The accurate diagnosis of skin diseases is often challenging due to the wide variety of symptoms and overlapping characteristics among different conditions[1]. Traditional diagnostic methods rely on manual examination by dermatologists, which can time-consuming and subjective[2]. There is no dept about the extent of the impact of machine learning techniques in all aspects of life at the present time, for example in industry, agriculture, the military field, medicine, and even understanding body language and other sciences[3][4][5]. In this study, we propose the use of metaheuristic algorithms to optimize the process of diagnosing skin diseases, with the goal of improving accuracy and reducing diagnostic time[6]. Skin diseases, also known as dermatological conditions, refer to a wide range of medical conditions that affect the skin. There are numerous types of skin diseases, each with its own symptoms, causes, and treatments. Here are some common examples: Acne, Eczema, Psoriasis, Rosacea, Dermatitis, Hives, etc[7][8]. Skin diseases pose a significant challenge in the field of healthcare, affecting millions of individuals worldwide. For efficient treatment and control of most disorders, swift and precise diagnosis is necessary. Accurate diagnosis of skin diseases is particularly important, but the multitude of skin diseases and their numerous manifestations make it a difficult task for dermatologists. To resolve this problem, scientists came up with Metaheuristics, powerful optimization techniques inspired by the processes taking place in nature such as neural networks, evolution, and swarm behavior. These algorithms have garnered a great deal of interest due to their innovative approach to solving complex problems in various domains, such as the field of medicine[9][10][11][12].

The purpose of this research is to compare and analyze different meta-heuristic algorithms in the context of skin disease diagnosis, The research aims to overcome limitations of current expert systems by developing a robust algorithm that optimizes the diagnostic process, ultimately improving the disease detection rate, minimizing misdiagnosis, and enhancing patient outcomes. During the research, the Comparison and comprehensive study of Several Meta-heuristic algorithms like Genetic algorithm, Particle swarm optimization, antlion optimization, and ACO (Ant Colony Optimization) will be performed and their performance would be analyzed based on the performance metrics like diagnostic accuracy, standard deviation, mean fitness, best fitness and worst fitness. The study will further explore the possibility of combining meta-heuristic algorithms with machine learning techniques to propose intelligent decision support systems for dermatologists. These proposed systems can be used by the dermatologist to deliver a faster, more accurate diagnosis by analyzing patient data, medical images and other clinical information.

2. Literature Review

This study aims to optimize skin disease diagnosis by using metaheuristic algorithms, aiming at constructing accurate and effective diagnostic models of skin diseases that can be conducive to clinical detection. Metaheuristic algorithms are computational techniques that can solve optimization problems in an efficient way through iterative exploration and improvement[13]. Research in this space over the years serves as strong evidence that this study will contribute to the overall progress in the field of skin diseases diagnosis using metaheuristic algorithms to optimize the performance of these diagnostic models by enhancing their accuracy, efficiency, and interpretability. In addition, by overcoming the challenge on what needs to be selected, which algorithms to apply and whether or not to hybridize, and the problem of optimizing deep learning models, our study will contribute to developing a robust tool that can be used for accurate and effective clinical detection of skin diseases[14]. In the field of skin disease diagnosis, many researches have been carried out to improve the accuracy and efficiency. Below, detailed explanation of several representative studies.

In the study [15], the authors introduce a discussion to compare and evaluate different metaheuristic algorithms such as genetic algorithms, particle swarm optimization, etc. of their working to diagnose a skin disease. It evaluates the degree of accuracy, convergence rate and efficiency of the algorithm to have the ideal diagnosis on the disease. Research [16] feature selection method based on metaheuristics algorithm is very important for diseases diagnosis, and the main aim of feature selection is to maintain the best accuracy and reduce the dimensionality of the data by selecting the informative feature set. Using the metaheuristic algorithms for feature selection is widely discussed in study [17], where a wide range of recent methods discussed for selecting the feature set that mostly generated nature-inspired characteristics and using classical methods including the ants colony algorithm and the genetic algorithm in the diagnosis field. In research [18], the authors hybridize the Sine Cosine Algorithm (SCA) for improving results in the diagnosis of skin diseases.

The hybrid system has shown optimum performance. In the article [19], there are several hybridization techniques are discussed by combining two or more metaheuristic algorithms for improving disease diagnosis. This paper discusses the synergistic effects of hybridizing algorithms like genetic algorithms with ant colony optimization or Grey Wolf Optimizer (GWO), to exploit the strengths of such algorithms to overcome the others. Furthermore, the proposed method in the research [20], emphasizes on the successful tuning of deep learning models for skin disease diagnosis utilizing metaheuristic algorithms. It explores how metaheuristic algorithms can be employed to fine-tune hyperparameters, architecture, and training processes of deep learning models, resulting in improved diagnostic accuracy. Table 1 below, summarizes the most effective used algorithms for the detection of skin diseases.

Table 1 Breif description of most used algorithms for skin diseases

No.	Ref.	Algorithm Name	Method	Brief Description
1	[15]	Genetic Algorithm	Metaheuristic-based diagnosis	Evaluated accuracy, convergence rate, and efficiency of metaheuristic algorithms for skin disease diagnosis.
2	[16]	Multiple Metaheuristic Algorithms	Feature Selection	Emphasized importance of feature selection for disease diagnosis, aiming to maintain accuracy and reduce dimensionality using metaheuristics.
3	[17]	Ant Colony Algorithm, Genetic Algorithm	Feature Selection	Discussed various methods for selecting feature sets in diagnosis, including nature-inspired characteristics and classical methods.
4	[18]	Sine Cosine Algorithm	Hybridization	Hybridized SCA for improving skin disease diagnosis, demonstrating optimum performance.
5	[19]	Grey wolf optimizer	Disease Diagnosis	Explored combining metaheuristic algorithms like Genetic Algorithm with Ant Colony Optimization or Grey Wolf Optimizer for improved diagnosis.
6	[20]	Whale Optimization algorithm	Deep Learning Model Tuning	Explored using metaheuristic algorithms for tuning hyper parameters, architecture, and training processes of deep learning models for diagnosis.

3. Rresearch Methodology

This research conducted a simple methodology to perform the typical par tof this project. It involves sequential actions starting with collecting a comprehensive dataset of skin disease images and associated clinical information. Also, the research trained various metaheuristic algorithms, such as PSO, ALO, GA, and ACO which are practically implemented and compared to determine their effectiveness in diagnosing skin diseases. The used algorithms are trained using a subset of the dataset and evaluated on a separate testing set to assess their performances. Below, a full description of the most important followed steps.

a. Data Collection

The source of the dermatology data used in this study is from Kaggle, https://www.kaggle.com/datasets/kmader/skin-cancer-mnist-ham10000/discussion/183083. The number of samples is (10015), features are (64), and the classes is seven. Table 2 shows the details of the dataset.

Table 2 details of the dataset

Name of disease	code	Class code	No. of instances
Actinic keratoses and intraepithelial carcinomae	akiec	0	327
basal cell carcinoma	bcc	1	514
benign keratosis-like lesions	bkl	2	1099
Dermatofibroma	df	3	115
melanocytic nevi	nv	4	6705
pyogenic granulomas and hemorrhage	vasc	5	142
Melanoma	mel	6	1113

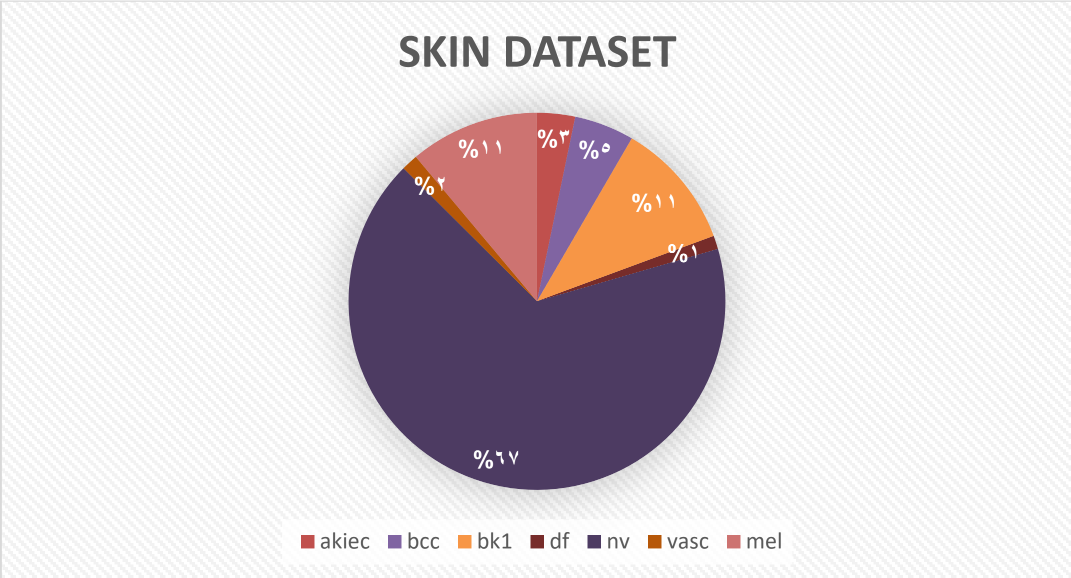

Figure 1 the general distribution of the dataset

3.2. Preprocessing

We performed a number of pre-processing steps to clean and prepare the dermatological data for analysis. The techniques for feature extraction and selection are using to reduce dimensionality and enhance algorithm performance.

3.3. Metaheuristic Algorithms:

The algorithms (GA, PSO, ALO, and ACO) are using to improve the diagnosis of skin diseases based on their efficiency in various applications and we will give a brief explanation of each algorithm. Figure 2 shows the general classification of the metaheuristic algorithms.

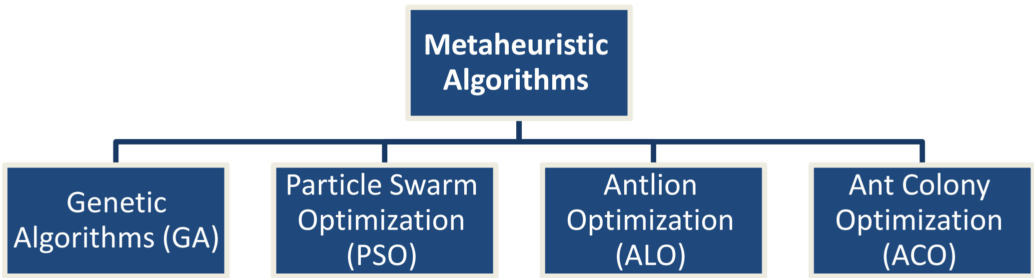

Figure 2 the general classification of the metaheuristic algorithms

3.3.1. Genetic Algorithms (GA)

Genetic algorithms are inspired by the principles of natural selection and genetics. They involve the iterative generation of potential solutions represented as chromosomes, which undergo crossover, mutation, and selection operations to evolve towards optimal solutions. Several studies have employed GA for feature selection, classification, and decision-making in skin disease diagnosis. These approaches have demonstrated promising results in terms of accuracy, sensitivity, and specificity[21].

3.3.2. Particle Swarm Optimization (PSO)
Particle swarm optimization is a population-based optimization method inspired by the movement of a swarm of particles in the search space. Each particle updates its position according to its own learning history and the knowledge accumulated by swarm. PSO has also been used to many related aspects of skin disease diagnosis, such as feature selection, parameter optimization and image segmentation. The resulting results show that using PSO leads to better diagnosis performance as well as less computational cost[22].

3.3.3. Ant Colony Optimization (ACO)
As the foraging behavior of ants, which communicate by pheromone trails to discover the shortest path between a nest and food sources. The methodology mimics the ant behavior and is used to solve optimization problems. In skin disease diagnosis, the ACO approach has been adopted for feature determination, lesion segmentation, and classification. Various studies show that the use of ACO methods has resulted in improved diagnosis accuracy and robustness[23].

3.3.4. Antlion Optimization (ALO)
Antlion optimization is inspired by antlions' predation; they capture prey by digging pits to trap them in a systematic manner. Antlion larvae adjust their pit over time while they wait for a prey to approach the crater. When food is detected, it falls into the pit, where they are easily devoured by antlion larvae. Antlion optimization works in a similar fashion as the pits get modified in many possible places. ALO is comparatively newer to GA and PSO and has also been widely used in skin cancer diagnosis. ALO is used mostly in feature selection, parameter tuning, and the classification tasks which yield accurate diagnosis in less processing time [24].

3.4. Experimental Design
The study is based on the experience of the four algorithms, each separately, and then the results are compiled and compared based on a set of measures. The data set was separated into two parts first part for training and second part for testing with a ratio of (70%, 30%) by using k-fold cross validation technique, ensuring unbiased evaluation. All experiments were carried out using MATLAB program. The evaluation metrics used to assess the performance of the algorithms such that (1) accuracy, (2) standard deviation, (3) worst fitness, (4) mean fitness, and (5) best fitness. Each metric is explained in detail below[25].
The accuracy is used to assess the efficiency of the FS operations on the dataset provided to the classifier. The classification accuracy calculating by equation (1).

$$\boldsymbol{Class\ Acc} = \frac{1}{M}\sum_{j=1}^{M}\frac{1}{N}\sum_{i=1}^{N}\boldsymbol{Mach}(\boldsymbol{Ci},\boldsymbol{Li}) \qquad (1)$$

M is representing the number of runs the algorithm to choose feature subset *N* is the number of points in the test set, *Ci* is representing the classifier output label for data point *i*, *Li* is representing class label reference.

Mean fitness: the average solutions that arose from the entire solutions package collected after executing an algorithm *M* of times. Mean Indicates the performance rate of the stochastic optimizer and it is calculated by the equation (2)

$$.\ Mean = \frac{1}{M}\sum_{i=1}^{M} g_*^i \qquad (2)$$

M is representing the number of runs the algorithm to choose feature subset, and g_*^i represent perfect solution yielded from run number *i*.

The standard deviation: reflects the variance in the best solutions achieved for *M* separate stochastic optimizer runs. It is utilized by optimizers as a standard for robustness and stability. Smaller numbers indicate that the optimizer converges to the same solution, whereas bigger values indicate a vast number of random outputs. The standard deviation calculating by equation (3).

$$Std = \sqrt{\frac{1}{M-1}\sum(g_*^i - Mean)^2} \qquad (3)$$

M is representing the number of runs the algorithm to choose feature subset, $g^i{}_*$ represent perfect solution yielded from run number *i*, and *Mean* is defined in equation (2).

Worst fitness: the worst solution produced from among the solution packages obtained when performing an algorithm *M* times. A negative solution is the worst-case scenario, which can be determined using equation(4)

$$Wors = Max_{i=1 g_*^i}^{M} \tag{4}$$

M is representing the number of runs the algorithm to choose feature subset, and $g^i{}_*$ represent perfect solution yielded from run number *i*.

Best fitness: a reduced fitness(cost) function obtained for an optimizer at each of an algorithm's *M* operations. The best solution is the most promising solution discovered, and it can be determined using equation (5)

$$Bst = Min_{i=1 g_*^i}^{M} \tag{5}$$

M is representing the number of runs the algorithm to choose feature subset, and $g^i{}_*$ represent perfect solution yielded from run number *i*.

3.5. Results Analysis

In the Table 3, a full description of the most relevant parameters employed in this research.

Table 3 setting values to the parameters

PARAMETER	VALUE
Number of runs	10
Number of Search agent	5
Number of iteration	100
Number of Features	64
Number of Instances	10015
Dimension	Equal to Features number

Accuracy is an important dimension to consider when applying the algorithm. The higher the accuracy, the better, the algorithm is. Each algorithm has a different level of accuracy. The algorithms that have been applied have different accuracy levels. ALO algorithm has the best accuracy, followed by the ACO algorithm then GA algorithm and the last is the PSO algorithm. Figure 3 shows the accuracy of each metaheuristic algorithm for a dermatology dataset.

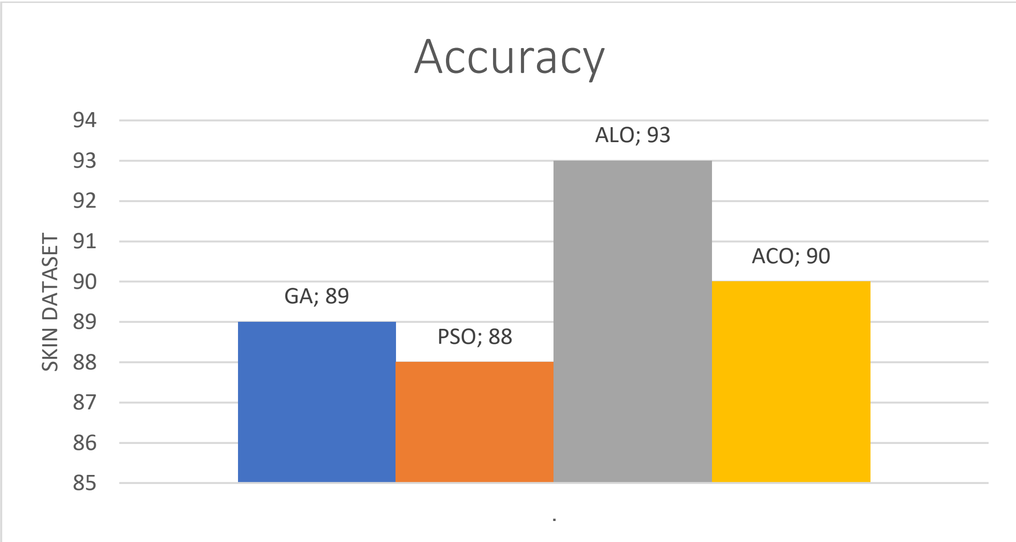

Figure 3 Accuracy levels of GA, PSO, ALO and ACO algorithms

In statistics, the standard deviation is used to find out the deviation in the values of the data. If the value of the deviation is low, then it is a great indicator, but if it is high, then it is a poor indicator. In this study, the observed results indicated the ALO algorithm is the best one while the PSO algorithm has less acuuracy than ALO algorithm. Figure 4 shows standard deviation of each metaheuristic algorithm for a dermatology dataset.

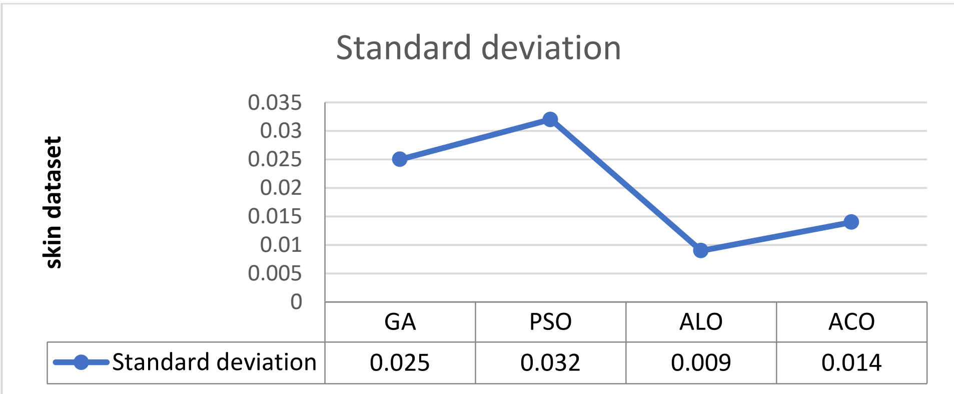

Figure 4 Standard deviation of GA, PSO, ALO and ACO algorithms.

In terms of statistical fitness, the best is always the minimum value. The comparison obtained in terms of statistical fitness is shown that the ALO algorithm is better than the three other algorithms in all statistical Fitness (Best, Worst, and Mean). Figure 5 shows mean fitness, worst fitness, and best fitness for each metaheuristic algorithm of a dermatology dataset.

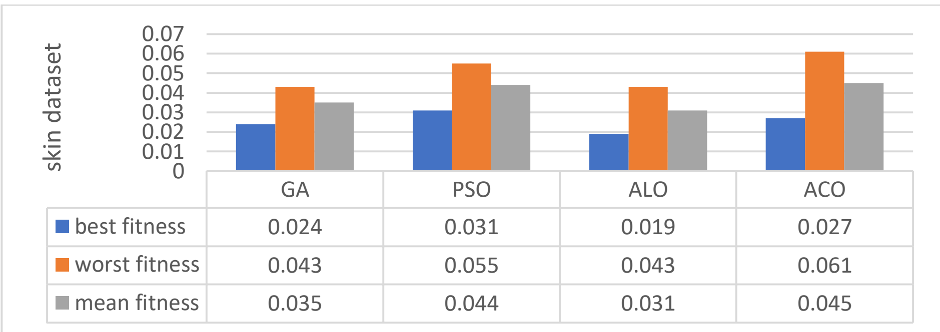

Figure 5 shows mean fitness, worst fitness GA, PSO, ALO, ACO.

4. CONCLUSION

This research has investigated the potential of advanced computational techniques for improved diagnosis of skin diseases. We have conducted a comparative study of several metaheuristic algorithms along with the traditional diagnosis techniques. Results show that genetic algorithm, particle swarm optimization, antlion optimization, and ant colony optimization algorithms can be used to increase the diagnostic accuracy of skin diseases. They result in the complete search of possible diagnosis and selection of the most optimal diagnosis after a small interval of time. Such comparative study will help dermatologists and health care professionals in the decision-making process, which will help in getting the correct and timely diagnosis. This will ultimately lead to early detection and prompt treatment, which will be beneficial for the patient. Nevertheless, it is crucial to understand that metaheuristic algorithms are still in their early stages, and have some limitations, such as proper parameter setting, choosing effective algorithms for the task, and suitably adaptive features of the dataset. Therefore, it is necessary to further examine the potential opportunities and challenges of metaheuristic algorithms in real-time clinical setups. However, the analysis obtained in this research suggests the possibility of metaheuristic algorithms being an effective solution for the purpose of skin disease diagnosis optimization. Their ability to improve accuracy, efficiency, and decision-making processes holds great potential for enhancing healthcare outcomes in dermatology. As technology continues to advance, it is expected that these algorithms will play an increasingly significant role in supporting dermatologists and healthcare practitioners in the diagnosis and treatment of skin diseases.

REFERENCES

[1] H. W. Lim et al., "The burden of skin disease in the United States," J. Am. Acad. Dermatol., vol. 76, no. 5, pp. 958-972.e2, 2017, doi: 10.1016/j.jaad.2016.12.043.

[2] Z. Xu, F. R. Sheykhahmad, N. Ghadimi, and N. Razmjooy, "Computer-aided diagnosis of skin cancer based on soft computing techniques," Open Med., vol. 15, no. 1, pp. 860–871, 2020, doi: 10.1515/med-2020-0131.

[3] C. J. Harrison and C. J. Sidey-Gibbons, "Machine learning in medicine: a practical introduction to natural language processing," BMC Med. Res. Methodol., vol. 21, no. 1, pp. 1–11, 2021, doi: 10.1186/s12874-021-01347-1.

[4] H. I. Mohammed, J. Waleed, and S. Albawi, "An Inclusive Survey of Machine Learning based Hand Gestures Recognition Systems in Recent Applications," IOP Conf. Ser. Mater. Sci. Eng., vol. 1076, no. 1, p. 012047, 2021, doi: 10.1088/1757-899x/1076/1/012047.

[5] Y. Jadhav and A. Barati Farimani, "Dominant motion identification of multi-particle system using deep learning from video," Neural Comput. Appl., pp. 1–15, 2022, doi: 10.1007/s00521-022-07421-z.

[6] V. R. Balaji, S. T. Suganthi, R. Rajadevi, V. Krishna Kumar, B. Saravana Balaji, and S. Pandiyan, "Skin disease detection and segmentation using dynamic graph cut algorithm and classification through Naive Bayes classifier," Meas. J. Int. Meas. Confed., vol. 163, Oct. 2020, doi: 10.1016/j.measurement.2020.107922.

[7] L. Tizek, M. C. Schielein, F. Seifert, T. Biedermann, A. Böhner, and A. Zink, "Skin diseases are more common than we think: screening results of an unreferred population at the Munich Oktoberfest," J. Eur. Acad. Dermatology Venereol., vol. 33, no. 7, pp. 1421–1428, 2019, doi: 10.1111/jdv.15494.

[8] S. S. Mohammed and J. M. Al-Tuwaijari, "Skin Disease Classification System Based on Machine Learning Technique: A Survey," IOP Conf. Ser. Mater. Sci. Eng., vol. 1076, no. 1, p. 012045, 2021, doi: 10.1088/1757-899x/1076/1/012045.

[9] N. S. Alkolifi Alenezi, "A Method of Skin Disease Detection Using Image Processing and Machine Learning," Procedia Comput. Sci., vol. 163, pp. 85–92, 2019, doi: 10.1016/j.procs.2019.12.090.

[10] S. Chakraborty et al., "Image based skin disease detection using hybrid neural network coupled bag-of-features," 2017 IEEE 8th Annu. Ubiquitous Comput. Electron. Mob. Commun. Conf. UEMCON 2017, vol. 2018-Janua, pp. 242–246, 2017, doi: 10.1109/UEMCON.2017.8249038.

[11] M. N. Al-Andoli, S. C. Tan, W. P. Cheah, and S. Y. Tan, "A Review on Community Detection in Large Complex Networks from Conventional to Deep Learning Methods: A Call for the Use of Parallel Meta-Heuristic Algorithms," IEEE Access, vol. 9, pp. 96501–96527, 2021, doi: 10.1109/ACCESS.2021.3095335.

[12] E. Vayena, A. Blasimme, and I. G. Cohen, "Machine learning in medicine: Addressing ethical challenges," PLoS Med., vol. 15, no. 11, pp. 4–7, 2018, doi: 10.1371/journal.pmed.1002689.

[13] C. W. Tsai, M. C. Chiang, A. Ksentini, and M. Chen, "Metaheuristic Algorithms for Healthcare: Open Issues and Challenges," Comput. Electr. Eng., vol. 53, pp. 421–434, 2016, doi: 10.1016/j.compeleceng.2016.03.005.

[14] T. Dokeroglu, E. Sevinc, T. Kucukyilmaz, and A. Cosar, "A survey on new generation metaheuristic algorithms," Comput. Ind. Eng., vol. 137, no. May, p. 106040, 2019, doi: 10.1016/j.cie.2019.106040.

[15] S. Chakraborty et al., "Detection of skin disease using metaheuristic supported artificial neural networks," 2017 8th Ind. Autom. Electromechanical Eng. Conf. IEMECON 2017, pp. 224–229, 2017, doi: 10.1109/IEMECON.2017.8079594.

[16] S. Kaur, Y. Kumar, A. Koul, and S. Kumar Kamboj, A Systematic Review on Metaheuristic Optimization Techniques for Feature Selections in Disease Diagnosis: Open Issues and Challenges, vol. 30, no. 3. Springer Netherlands, 2023. doi: 10.1007/s11831-022-09853-1.

[17] R. Diao and Q. Shen, "Nature inspired feature selection meta-heuristics," Artif. Intell. Rev., vol. 44, no. 3, pp. 311–340, 2015, doi: 10.1007/s10462-015-9428-8.

[18] S. S. Mohammed and J. M. Al-Tuwaijari, "Skin disease classification system based on metaheuristic algorithms," AIP Conf. Proc., vol. 2475, no. March, 2023, doi: 10.1063/5.0102907.

[19] A. Kumar, Lekhraj, S. Singh, and A. Kumar, "Grey wolf optimizer and other metaheuristic optimization techniques with image processing as their applications: a review," IOP Conf. Ser. Mater. Sci. Eng., vol. 1136, no. 1, p. 012053, 2021, doi: 10.1088/1757-899x/1136/1/012053.

[20] L. Zhang, H. J. Gao, J. Zhang, and B. Badami, "Optimization of the Convolutional Neural Networks for Automatic Detection of Skin Cancer," Open Med., vol. 15, no. 1, pp. 27–37, 2020, doi: 10.1515/med-2020-0006.

[21] T. Alam, S. Qamar, A. Dixit, and M. Benaida, "Genetic algorithm: Reviews, implementations and applications," Int. J. Eng. Pedagog., vol. 10, no. 6, pp. 57–77, 2021, doi: 10.3991/IJEP.V10I6.14567.

[22] D. Wang, D. Tan, and L. Liu, "Particle swarm optimization algorithm: an overview," Soft Comput., vol. 22, no. 2, pp. 387–408, 2018, doi: 10.1007/s00500-016-2474-6.

[23] S. Katiyar, Ibraheem, and A. Q. Ansari, "Ant Colony Optimization : A Tutorial Review Ant Colony Optimization : A Tutorial Review Department of Electrical Engineering Corresponding Author : (Email : aqansari@ieee.org)," no. August, 2015.

[24] R. . Rajeswari, K. . Kalaiselvi, N. . Jayashri, P. . Lakshmi, and A. . Muthusamy, "Meta-Heuristic Based Melanoma Skin Disease Detection and Classification Using Wolf Antlion Neural Network (WALNN) Model", Int J Intell Syst Appl Eng, vol. 12, no. 9s, pp. 87–95, Dec. 2023.

[25] Q. Al-Tashi, S. J. Abdul Kadir, H. M. Rais, S. Mirjalili, and H. Alhussian, "Binary Optimization Using Hybrid Grey Wolf Optimization for Feature Selection," IEEE Access, vol. 7, no. c, pp. 39496–39508, 2019, doi: 10.1109/ACCESS.2019.2906757.

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