International Journal of Basic and Applied Sciences, 14 (SI-1) (2025) 228-233

International Journal of Basic and Applied Sciences

Website: www.sciencepubco.com/index.php/IJBAS
https://doi.org/10.14419/g6ys1k25
Research paper

Optimization Methods for Adaptive and Dynamic Particle Swarms for Accurate Real-Time Localization in Healthcare Settings-A Comprehensive Survey

A. H. Jainab Ruxana [1] *, Dr. S. Malathy [2]

[1] *Ph. D(ECE) Scholar, Department of ECE, Karpagam Academy of Higher Education, Coimbatore, India*
[2] *HOD/ Professor, Department of ECE, Karpagam Academy of Higher Education, Coimbatore, India*
**Corresponding author E-mail: jainabruxanaah@gmail.com*

Received: May 15, 2025, Accepted: May 31, 2025, Published: June 7 2025

Abstract

Localization in healthcare facilities has the potential to enhance various medical treatments. Therefore, suitable enabling communication technology is necessary for an accurate locating system in this setting. Unfortunately, many problems with commonly used technologies like WiFi, Bluetooth, and RFID make them unsuitable for hospital localization. These problems include expensive implementation costs, weak signals, inaccurate estimates, and possible interference with medical devices. This paper finds new solutions since existing technologies are becoming more expensive to adopt and maintain and are not accurate enough for use in dynamic medical settings. To achieve precise control over the robot's movement, cutting-edge sensors and control systems are combined. The study and creation of a system known as advancements in sensor technology and optimization of control algorithms accompany dynamic accuracy compensation. The fundamental principle behind this paper is to obtain better operational precision by continuously adjusting the controller's settings based on the real-time data gathered by sensors.Particle Swarm Optimization (PSO) improves the model's overall performance by fine-tuning the hyperparameters.When it comes to life-saving equipment, this improved precision is crucial for meeting the requirement for exact positioning in complex and ever-changing healthcare settings. The findings show that PSO makes the model much better, which gives a solid foundation for building high-tech Healthcare localization systems. Compared to more traditional positioning techniques, the suggested localization algorithm outperforms them in terms of localization error and location estimation.

Keywords: *Particle Swarm Optimization (PSO); Healthcare Environment; Real-time Localization.*

1. Introduction

Due to its ability to maximize resources, keep tabs on crucial operations, and make decision-making easier, localization systems are important in today's society. One practical application of these systems is tracking the interior locations of mobile devices, aircraft, vehicles, and storage goods [1]. There are clear theoretical and practical advantages to deploying such systems in healthcare settings, and their implementation represents a major step forward. According to a comprehensive scoping assessment, indoor positioning systems (IPSs) play an essential role in healthcare facilities. These systems enhance hospital resource management, patient care, and efficiency. Nurses and other frontline medical professionals may improve reaction times, workload, and healthcare delivery by precisely and quickly locating themselves, clients, healthcare supplies, and other required resources [2-3].

Various uses in healthcare facilities demonstrate the adaptability and usefulness of localization systems. Among them are, among other things:

Medical device tracking: keeping tabs on where and how medical equipment, such as defibrillators and portable imaging machines, is to make sure it doesn't go lost and is always available when needed.Healthcare providers may keep tabs on where their patients are using patient monitoring. When it comes to mental health facilities or individuals with diseases like Alzheimer's, where ensuring their safety and preventing them from roaming is of the utmost significance, this function is indispensable [4-5].

Staff collaboration: One-way hospitals might improve their efficiency is by sharing real-time data on where their medical staff members are. Thisenhances the facility's ability to respond to emergencies and provides high-quality patient care by facilitating the rapid formation of teams and the more efficient distribution of staff resources [6].

Assists patients and visitors in navigating the intricate hospital layouts. Numerous end users benefit from these apps, including patients, medical staff, and hospital managers. These include improved productivity, which streamlines healthcare shipment; better patient care, which ensures prompt and suitable actions; greater security, which protects clients and employees; and a substantial reduction in asset

destruction as well as mismanagement, which optimizes hospital resource use. These tangible benefits improve healthcare efficiency, effectiveness, and patient-centeredness [7-8].
The case for using localization systems in healthcare settings is strong in light of the many benefits. Nevertheless, there are several obstacles to overcome in creating and deploying such systems, including reducing electromagnetic interference with medical devices, attaining pin-point accuracy, and efficiently controlling expenses [9]. Comprehensive testing and the implementation of complex technical solutions are necessary to guarantee that these cutting-edge technology systems work in tandem with critical medical equipment without interfering with one another [41]. Additionally, in healthcare settings, where even little variations may significantly impact patient care results, the precision of localization systems is paramount [10]. It calls for meticulous system design and implementation to meet the complicated demands of clinical operations, emphasizing accuracy and dependability. Here, GPS tracking is among the most popular methods for keeping tabs on gadgets in the great outdoors. Indoor locations like hospitals, subways, mines, and hostile zones might experience certain imprecisions with this system owing to attenuation induced by obstructions [40]. To overcome this significant obstacle, we need more reliable and advanced methods of localization backed by trustworthy and efficient communication networks [11-12].
PSO does a good job of regulating the ratio of exploration to exploitation. In the exploration phase, particles scour the cosmos, but in the exploitation phase, they zero in on areas with the most profit potential [13]. The effectiveness of PSO is directly proportional to the degree to which exploration and exploitation are balanced. Given its many benefits, PSO has emerged as a strong contender for optimizing a broad range of optimization problems and applications in the real world [39]. Two types of PSO review articles are found in the literature: those focusing on PSO and its applications in a particular sector and those examining different versions of PSO. Despite a study of current work on PSO, the authors failed to consider PSO in its binary form and instead focused on PSO in continuous search space. Not to mention that the writers glossed over several crucial details, including how to use PSO for optimization issues [14].
Meanwhile, PSO can search inside a certain range and needs fewer parameters for design. But PSO is notoriously sluggish when it comes to searching regions for particles [38]. It may get stuck in a local location and cannot change the convergence speed. Consequently, other enhanced PSO variants have been suggested using distinct optimization strategies. Nevertheless, this study uses a smaller amount of acceleration data and many unknown factors, allowing PSO to bypass the local optimum, accelerate convergence, and reduce the number of parameters needed [15-16]. Updates to the weight and acceleration constant in the Improved PSO (Improved PSO) Algorithm slowed convergence. It reduced the capacity to leap out of the local optimum, making it more difficult to locate the optimal solution. The study on PSO was summarized in this publication; however, it only included binary PSO variations [37]. Recent survey work on PSO explores some PSO versions in discrete and continuous environments. Hybrids of PSO and other popular meta-heuristic algorithms, including ACO and gravitational search algorithm (GSA), are also absent from the text. Plus, it ignores any other possible technical uses of PSO in favour of its employment in solar photovoltaic systems [17-18]. Table 1 concisely summarises the most up-to-date and relevant PSO survey articles [36].

2. A complete survey

As suggested in [19], the paper addresses the unique needs of healthcare facilities for accurate localization and monitoring of critical devices using Visible Light Communication (VLC) as a fundamental technology. The three transmission LEDs in the recommended setup have multiple wavelengths using the existing electrical equipment. Using the PSO algorithm enhances the reliability of localization; for instance, at a height of 1 m, the error decreases from 11.7 cm to 0.5 cm when using the suggested technique.
The authors of [20] present a localization method that integrates two hybrid algorithms: ELPSO (ensemble learning via particle swarm optimization) and PSO-BPNN (reverse propagation neural network technique enhanced by particle swarm optimization). Additionally, the accuracy of error reduction has been evaluated through various simulation methods. The suggested methods outperform the standard procedures in research regarding precision in localization. New localization algorithms using optimum strategies minimize the error value. The localizing error range is about 2.7 cm, which is lower than comparable designs found in research.
Using a two-dimensional picture that includes the input signal intensity indicators for the x and y-axes, the authors of the article [21] trained a Convolutional Neural Network (CNN) based positioning model. Researchers used an upgraded version of the particle swarm optimization (PSO) based neuro-evolution method to build CNN's many layers and make them interactively optimized for performance. Contrasted with other previous approaches, the testing findings reveal that the suggested optimized CNN-based approach achieves a high level of precision (97.92% with 2.8% error) when it comes to tracking the positions of a moving user in a complicated facility requiring extensive validation.
By moving the emphasis from chemicals to particulate material (PM) in these settings, the research [22] contributes to the discipline. Before conducting comprehensive 3D source localization research, an adapted multi-robot method was used to conduct an in-depth analysis of circulation interactions and PM movement under fragile circulation circumstances. Two approaches utilized in these experiments were the Whale Optimization Algorithm (WOA_3D) and Particle Swarm Optimization (PSO_3D). Blending understandings of the intricacies of PM behaviour with empirical improvements, these findings emphasize the significance of tackling PM settling to enhance PM localization efforts.
In [23], two niche-based particle-swarm optimization (PSO) techniques were proposed for the concurrent localization of several contaminants in unstable airflow fields: Niche-DPSO and RSNM-DPSO. They choose the MUST experiment as our case study because of its intricate design and tightly packed impediments. According to the findings and the methods used, Niche-DPSO and RSNM-DPSO performed similarly when pinpointing various contamination sources.
The research [24] suggests using the well-known particle swarm optimization approach for indoor localization using WiFi biometrics; to improve performance, it suggests using a novel two-panel signature heterogeneity model to describe biometric comparability. Furthermore, experimental verification of the localization method's effectiveness is provided. With precision in localization gains of 15.32%, 15.91%, 32.38%, and 36.64% compared to KNN, SVM, LR, and RF, respectively, the suggested localization approach surpasses traditional methods.
In [25], The study proposes a method for estimating SOH and RUL simultaneously using an enhanced Particle Swarm Optimization Extreme Learning Machine (PSO-ELM). This method utilizes the PSO-ELM model to precisely estimate SOH and forecast RUL for lithium-ion batteries by screening multivariable discharge data for processing using Pearson coefficients as health parameters. This work presents an improved model for evaluating the SOH and RUL of batteries made from lithium-ion, which outperforms the classic machine learning system in terms of accuracy in forecasting.
The research [26] uses novel deep-learning methods to pinpoint where oral illness is present. The most successful feature mining strategies, such as visual and pattern-based capabilities, are used in this study. Selecting the optimal feature follows feature extraction and is accomplished using the BeePCNN algorithm. The last step is to sort these characteristics using Deep Learning. The computational demands of

CNN are reduced using the creative FGPSOCNN. An additional real-time Arthi Scan Hospital data set is reviewed. Experimental results show the innovative FGPSOCNN outperforms state-of-the-art methods.

Radiofrequency ablation (RFA) is a treatment option for liver cancers, and this research [27] looks at how well a bioinspired Particle Swarm Optimization (PSO) method for tuning PID controllers works. A continuous-time transmission function of the ninth order was obtained from ex vivo investigations. The simulation results were remarkable after using PSO to improve the PID settings. The bioinspired PSO-based PID controller's roll-off effect mitigation during RFA reduced partial tumor ablation. The PSO-based PID tuning technique advances radiofrequency excision operations by realistically improving RFA effectiveness.

To overcome these shortcomings, the research team behind the paper [28] proposes a skin cancer classification system that uses active learning (AL) and particle swarm optimization (PSO) together. To maximize the performance of classifiers with minimal tagging costs, the AL approach chooses which untreated cases can be most interesting for professional interpretation. Many Convolutional Neural Network (CNN) models were trained using this approach on the HAM10000 skin lesion collection. This study's results suggest that skin cancer diagnosis using AI may be sped up by combining AL and PSO.

To improve the results of brain-computer interface (BCI) technology-assisted rehabilitation for strokes, the work [29] investigates the use of deep-learning algorithms enhanced via Particle Swarm Optimization (PSO). The findings prove that PSO greatly improves the efficiency of those designs, offering a solid basis for creating cutting-edge treatment programs. In addition to providing a more tailored treatment treatment to stroke patients, it enhances the precision of visual categorization.

In [30], a strategy dubbed "flexible precision replacement" is investigated and developed in conjunction with enhanced electronic sensors and optimized control algorithms. The modified robot demonstrates improved stability and precision in fine-grained actions, and the testing findings reveal a decreased oscillation region in sensor information. In addition to providing theoretical backing for healthcare robots' further growth and use, this research sets the groundwork for advances in technology in adjacent domains, suggesting that these robots will have far-reaching potential applications in the future of medicine.

Genetic improvement and deep neural networks improve classification values and diagnosis time to streamline dermatological cancer operations in [31]. The revolutionary hyperparameter-adjusting methodologies of Particle Swarm Optimization and Bat Method enhance MobileNet, Xception, and Insomnia. Through the web interaction, Heroku hosted cloud solution customers can provide skin lesion photos for Deep Neural Network (DNN) categorization as carcinoma or non-melanoma. This technological innovation makes skin cancer detection more practical and feasible for dermatology and medical professionals.

This study seeks to improve medical imaging oral cancer detection. A unique and successful oral cancer diagnosis method uses an upgraded deep belief network (DBN) and a convolutional neural network (CNN) [32]. PSOBER is a novel optimization approach that combines PSO with BER. Optimize CNN and DBN design parameters using it. To demonstrate the method's relevance and stability, researchers use Wilcoxon mean signed-rank exams and one-way ANOVA.

By including an effect of the approach and making use of the Hamming radius measurement, the Particle Swarm Optimization (PSO) methodology is improved [33] to make the resulting feature descriptions more accurate for use in augmented reality (AR) healthcare applications. It improves the accuracy and clarity of the information points used for analysis and remedy preparation, increasing the dependability of the procedure for extracting features. Furthermore, to improve the accuracy and reliability of dental health care, the Hamming radius metric is used to measure the consistency among numerous feature vectors extracted from dental pictures.

In their study, the authors used the Bee-Foraging Learning-based Particle Swarm Optimization (BFL-PSO) method to get the optimal key for transferring healthcare data to the cloud, ensuring the utmost degree of security. If a healthcare company is going to put its faith in and make use of the cloud computing platform, two things must be ensured: confidentiality and safety. In the current study, researchers provide retrieval and disinfection procedures for creating keys from collected data and for making a multiple-purpose mechanism that considers the disclosure ratio, extent of change, and knowledge protection ratio. The proposed method outperforms state-of-the-art security techniques, according to its efficiency analysis.

To alleviate the scheduling issue the HHC staff faces, the research [35] suggests a Two-Level particle swarm optimization variation (2LPSO) that incorporates doubt leadership and worker burden balancing. This variant would help to prevent overtime labour. By addressing two scenarios—patient cancellations and demands for additional patients—this research offers a strategy for effective planning within acceptable computation durations. The computational outcomes of this research prove that our method is efficient and productive. For enhanced customer satisfaction in response to new patient requests or cancellations, the suggested optimizing framework gets robust planning profitability by balancing staffing times to meet patient availability insights boundaries.

Table 1: Comparative Analysis of the Localization of PSO Algorithms in Different Healthcare Applications

Author name	Advantages	Limitations
Candia et al.,	According to the results, when it comes to VLC-based locating frameworks, the PSO algorithm consistently reduces overall losses more than its competitors.	It's worth mentioning that a larger processing expense accompanies the PSO algorithm's improved accuracy.
Lakshmi et al.,	Particles can refine their search areas and get more precise interior locations with this creative learning method.	It is possible to improve noise patterns and associated absorption screens in real time to adapt to the dynamic nature of the monitored circumstances.
Danshi Sun et al.,	When monitoring indoor locations using the RSSI, devices must be designed to accommodate complicated disturbance frequencies. To effectively monitor the interior position of a moving user in complicated internal architecture settings using BLE beacons, researchers provide a system based on enhanced convolutional neural networks (CNN).	Removing incorrect signals might leave the precise reference without geographic information, like where only transmissions from improper angles have been detected, and the user's subject and building parts were occluded.
Li et al.,	Researchers used a multi-robot system to perform comprehensive 3D source localization tests to study airflow kinematics on particulate matter movements under moderate ventilation.	It is possible that speeds reported at the minimal recognition threshold of 0.05 m/s, the acoustic thermometer utilized in this research, indicate even lower real values.
Zhang et al.,	In metropolitan areas, where different forms of pollution interact, it is crucial to find several sources at once to identify and mitigate them quickly, protecting the health and safety of city dwellers.	The main challenge when using active detecting robots to find contaminants is effectively detecting pollution sources inside a certain zone using one or more collaborating robots.
Zheng et al. ,	The localization inaccuracy of the suggested technique is the lowest across all distributions (median, the highest, lowest, high quarter, and less quarter), and there are no severe outliers.	Given the uncertainty of the alteration connection between the biometric field and the external reference field, it isn't easy to achieve high-accuracy localization while assigning the appropriate weights.

Zhang et al.,	It may be used for green power stations and electric transportation due to its versatility. ELM and PSO can withstand data submission turbulence to anticipate the SOH of batteries and RUL accurately.	Optimizing particles in a swarm requires parametric adjustment (inertia weight, particle density). Despite its advantages, PSO's repetitiveness may increase processing time for huge data sets or massive systems.
Dharani et al.,	Fuzzy thinking addresses healthcare data biases and anomalies to aid complicated decisions. PSO and incremental algorithms minimize CNN redundancies and accelerate processing. The technique may improve oral cancer survival via early diagnosis and treatment.	Compression and learning CNN computation may prevent it from working in low-resource contexts. Size, variety, and the calibre of learning data impact system efficacy. Wrong information might hurt outcomes. Big files and sophisticated models take time. However, repeating PSO and genetic algorithms improves productivity.
Faria et al.,	PSO quickly finds PID settings for physical actuator modification. Operators may avoid lengthy manual modifications using PSO's automated tuning. The method is valuable for numerous biological uses and can improve healthcare technology and procedures.	PSO could arrive too quickly to local optimal values, producing PID controller tuning issues. Technical expertise, programs, and hardware upgrades must incorporate the updated PID controller with RF sterilization machines. PSO-tuned PID controllers reflect patient-specific hepatocyte electrophysiological and thermal qualities.
Mandal et al.,	Its adaptability to skin disorder subtypes and imagery benefits it in various scenarios. Expanding the approach identifies tumours and abnormalities. Continuous learning reduces adjusting in tiny collections by selecting the more significant occurrences.	PSO and Iterative training might slow the processing of massive data sets or CNN setups. Fine-tuning PSO parameters affects results in unoptimized throughput. Substantial instructional classification demands subject expertise, which is costly and laborious.
Ayman et al.,	During recuperation, patients and physicians may get real-time input and ideas from strengthened deep computing models. The technology adapts to patient progress for ongoing learning. Smart technologies and interactive advice may keep patients.	PSO with deep learning needs EEG and sensors for stroke rehabilitation. Systems may be complicated by merging. Complex algorithms with vast feature spaces can make it harder to optimize PSO due to redundancy. Many with different health histories, therapeutic requirements, and other characteristics might vary from limited data algorithms.
Wang et al.,	The device is now more dependable and robust, lowering the danger of failure during essential treatment. Enhanced materials allow the device to diagnose and perform less intrusive surgery. The research uses advanced mathematical techniques like optimization software and FEA to develop better based on research.	Owing to the multitude of life situations, optimization methods may be inaccurate due to theoretical expectations. The necessity for sophisticated factories to adopt fresh designs may raise supply sophistication and cost.
Mundada et al.,	Biologicallyinspired adaptation helps DNNs accommodate incomplete or noisy diagnostic imaging data. Optimizing from the network's architecture reduces computation redundant work, speeding development and forecast. Expandable expands healthcare diagnosis programs to accommodate increasingly complex systems and input.	Optimized models may overfit training data for limited or undiversified datasets, limiting their performance for fresh samples. Bio-inspired algorithms for large-scale DNN systems are iterative; therefore, tuning them may take time.
Myriam et al.,	This hybrid approach can evaluate images and clinical data, making it adaptable for numerous diagnostic circumstances. The missing and noisy data strategy works consistently in real life. Meta-heuristics optimizes machine learning model parameters without human intervention.	Designing and comprehending two meta-heuristics is harder than standalone algorithms. A broad, diversified, and exceptional training dataset boosts model performance. Lack of variety or data from real life may overfit the algorithm.
Taher et al.,	AR simulations are customized for each patient's oral anatomy and treatment. PSO improves dental anatomy modelling for complex surgical planning and instructional simulations. Highly effective augmented reality helps dentists practice and develop.	AR needs accurate 3D dental scans and radiographs. Reminding and changes may be required in dentists and medicine. Highly computational methods of PSO optimization may delay popularity.
Irshad et al.,	Resource minimization and computation reduction improve security. Big healthcare cloud systems may utilize it to handle many users and complicated datasets.	Integrating the system with healthcare data centres requires technical expertise. Processing expenses may hinder its efficacy for high-traffic internet networks and immediate assurance.
Zarrouk et al.,	The method manages last-minute staff absences and patient demands for seamless care. It reduces travel, fits individual needs, and regulates exertion. This method may address emergencies, ongoing assistance, and other medical needs.	Efficiency may ignore patient-physician and societal norms. Remote medical providers may schedule and travel large distances to test the method. Optimized samples or variables may render the algorithm unsuitable for surprises.

The growing complexity of several optimization issues necessitates more investigation into the investigation and enhancement of various optimization algorithms. The PSO method is a powerful resource for tackling many optimization problems. While learning the global optimum is the primary goal of the update approach for the basic PSO, it consistently converges too quickly. It performs poorly on various complicated optimization tasks, especially when it comes to multimodal issues. Classical PSO's learning process is straightforward and quick to implement, but it's vulnerable to problems like "oscillation" and the "two steps forward, one step back" phenomenon. To circumvent these two issues and generally boost search performance, PSO researchers have developed new effective learning algorithms. One sub-swarm relied on the comprehensive learning method to manage the particles' global search.

The healthcare, environmental, industrial, commercial, smart city and general sectors of PSO applications are organized in a thorough taxonomy. To facilitate the efficient and successful implementation of PSO in future real-world applications, it is important to identify the challenges each kind of PSO application will likely encounter. This leads us to propose PSO applications in a specific context by reviewing research on key aspects of these difficulties. Environmental PSO applications encompass a wide range of topics, including economic emission dispatch, PhotoVoltaics (PV) parameter identification, pollution forecasting, plant segmentation and classification, water quality monitoring, flood control and routing, and many more. Therefore, this work offers a taxonomy based on various PSO applications in specific research studies that deal with and explore unique subjunctives. Taking into account the issues and difficulties inherent in different kinds of PSO applications, started by classifying PSO applications into several types and then detailing the primary topics that received extra emphasis in each kind. Since most PSO applications share commonalities, the taxonomy included a new category for research that addressed broad issues: "general aspects." This category included studies that offered solutions to specific problems in PSO applications. So, every kind of PSO application may benefit from introducing a new conceptual approach based on research deemed to have general elements.

3. Conclusion

Although PSO is useful in a variety of contexts, there are still obstacles that need to be overcome, and new avenues of investigation should be considered. Researchers' interest in PSO has grown in recent years and has been used in various fields. Yet, important concerns and challenges persist. Consequently, academics and researchers must put in more time and energy to solve the issues that might prevent PSO from being widely used. In addition, new PSO methods should be developed by pursuing more effective strategies and ideas. According to the results, a consistently decreased average of mistakes shows that the PSO algorithm performs better with localization techniques in healthcare environments. It should be mentioned that a larger computational cost accompanies the PSO algorithm's improved accuracy. Thus, it is essential to carefully weigh the trade-offs between accuracy and processing efficiency when designing actual applications.

Improving the PSO algorithm's computing efficiency without sacrificing its accuracy for real-time placement is one possible subject for future research. Suggesting and verifying ways to enhance the PSO algorithm is also important so that it may be used in 3D settings. This next technique will investigate optimal configurations of the PSO algorithm, including cognitive factors, inertia, particle quantity, and iterations, to find links between the findings' accuracy and the various configurations. Further, in the case under consideration, it is paramount to evaluate potential for exploring other configurations to improve the algorithm's initialization parameters, namely the distribution and quantity of particles. Over the last 20 years, the Particle Swarm paradigm has seen revolutionary changes and remarkable achievements. The search process was difficult because of the following factors: numerous local optima, the search space's arbitrary nature, the difficulty of applying traditional mathematical abstractions to a diverse set of objective functions, and the lack of a priori guarantees regarding the discovery of any optima. Unlike their deterministic counterparts, particle swarm optimizers have proven effective in various objective functions, including continuous and discontinuous ones, tractable and intractable ones, and even those where initialization makes solution quality sensitive. There are a number of important issues that the PSO industry should focus on more. This system employs white lights of several wavelengths; future research should compare its advantages to those of single-wavelength systems. This research will take into account the following factors: performance, accuracy, computational complexity, costs, and necessary hardware. Finally, further research will focus on the optical filters that are required by the system. Complete experimental verification and analysis of the PSO system requires this as a crucial step. Ensemble optimizers are promising, but they don't fix the underlying issues with the basic PSO. For future applications, researchers should concentrate on theoretical difficulties such as the particle explosion problem, loss of particle variety, and stagnation at local optima in order to establish a unified algorithmic framework with better self-adaptation and fewer user-specified customizations.

References

[1] Sohail, N., Khan, A. A., & Memon, A. B. (2023, August). Swarm Robots on a Mission: Optimizing Inspections with Fuzzy Logic and Particle Swarm Optimization. In *2023 20th International Bhurban Conference on Applied Sciences and Technology (IBCAST)* (pp. 19-25). IEEE. https://doi.org/10.1109/IBCAST59916.2023.10712943.

[2] Narang, I., & Kulkarni, D. (2023). Leveraging Cloud Data and AI for Evidence-based Public Policy Formulation in Smart Cities. In Cloud-Driven Policy Systems (pp. 19-24). Periodic Series in Multidisciplinary Studies.

[3] Han, F., Abdelaziz, I. I. M., Ghazali, K. H., Zhao, Y., & Li, N. (2023). Optimized range-free localization scheme using autonomous groups particles swarm optimization for anisotropic wireless sensor networks. *IEEE Access*, *11*, 26906-26920. https://doi.org/10.1109/ACCESS.2023.3257567.

[4] Fakhrian, M., Jazayeri, S., Pirali Zefrehei, A. R., & Hedayati, A. A. (2022). Dietary effects of extruded feed on biochemical and hematological indices of Rainbow trout (Oncorhynchus mykiss). International Journal of Aquatic Research and Environmental Studies, 2(1), 9-15. https://doi.org/10.70102/IJARES/V2I1/2.

[5] Xie, S., Yu, X., Guo, Z., Zhu, M., & Han, Y. (2023). Multi-Output Regression Indoor Localization Algorithm Based on Hybrid Grey Wolf Particle Swarm Optimization. *Applied Sciences*, *13*(22), 12167. https://doi.org/10.3390/app132212167.

[6] Wei-Liang, C., & Ramirez, S. (2023). Solar-Driven Membrane Distillation for Decentralized Water Purification. *Engineering Perspectives in Filtration and Separation*, 1(1), 16-19.

[7] Sultana, N., Huq, F., Roy, P., Razzaque, M. A., Rahman, M. M., Akter, T., & Hassan, M. M. (2025). Context aware clustering and meta-heuristic resource allocation for NB-IoT D2D devices in smart healthcare applications. *Future Generation Computer Systems*, *162*, 107477. https://doi.org/10.1016/j.future.2024.08.001.

[8] Yadav, R. K., Mishra, A. K., Jang Bahadur Saini, D. K., Pant, H., Biradar, R. G., & Waghodekar, P. (2024). A Model for Brain Tumor Detection Using a Modified Convolution Layer ResNet-50. *Indian Journal of Information Sources and Services, 14*(1), 29–38. https://doi.org/10.51983/ijiss-2024.14.1.3753.

[9] Manimegalai, L., Neelima, P., Pandian, A. S., Bandili, S. K., Ganesh, B. J., & Ramachandran, L. (2024, June). An In-Depth Prediction on IoT-Driven Precision Location Using Particle Swarm Optimization. In *2024 15th International Conference on Computing Communication and Networking Technologies (ICCCNT)* (pp. 1-7). IEEE. https://doi.org/10.1109/ICCCNT61001.2024.10724931.

[10] Mehra, A., & Iyer, R. (2024). Youth Entrepreneurship as a Catalyst for Inclusive Economic Growth in Developing Nations. *International Journal of SDG's Prospects and Breakthroughs, 2*(3), 13-15.

[11] Tariq, S. M., & Al-Mejibli, I. S. (2023). WSN Localization Method Based on Hybrid PSO-GRNN Approach. *International Journal of Intelligent Engineering & Systems*, *16*(5). 717-727. https://doi.org/10.22266/ijies2023.1031.60.

[12] Wei, L., & Johnson, S. (2024). Standardized Terminology for Symptom Reporting in Telemedicine Consultations. *Global Journal of Medical Terminology Research and Informatics*, *2*(2), 14-17.

[13] Hassani, S., & Dackermann, U. (2023). A systematic review of optimization algorithms for structural health monitoring and optimal sensor placement. *Sensors*, *23*(6), 3293. https://doi.org/10.3390/s23063293.

[14] Chaubey, C., & Khare, R. (2024). Enhancing quality of services using genetic quantum behaved particle swarm optimization for location dependent services. *Sādhanā*, *49*(2), 179. https://doi.org/10.1007/s12046-024-02518-8.

[15] Saifullah, S., & Dreżewski, R. (2024). Advanced medical image segmentation enhancement: a particle-swarm-optimization-based histogram equalization approach. *Applied Sciences*, *14*(2), 923. https://doi.org/10.3390/app14020923.

[16] Ganduri, K. V., & Pathri, B. P. (2024). Swarm Intelligence in Action: Particle Swarm Optimization and Rendezvous Algorithms for Swarm Robotics. *Journal of Field Robotics*. https://doi.org/10.1002/rob.22466.

[17] Ala, A., Simic, V., Pamucar, D., & Bacanin, N. (2024). Enhancing patient information performance in internet of things-based smart healthcare system: Hybrid artificial intelligence and optimization approaches. *Engineering Applications of Artificial Intelligence*, *131*, 107889. https://doi.org/10.1016/j.engappai.2024.107889.

[18] Chai, S., & Guo, L. (2024). Edge Computing with Fog-cloud for Heart Data Processing using Particle Swarm Optimized Deep Learning Technique. *Journal of Grid Computing*, *22*(1), 3. https://doi.org/10.1007/s10723-023-09706-6.

[19] Umaamaheshvari, A., Sivasankari, K., Suguna, N., Kshirsagar, P. R., Tirth, V., & Rajaram, A. (2023). RETRACTED: Optimization technique for optimal location selection based on medical image watermarking on healthcare system. *Journal of Intelligent & Fuzzy Systems*, *45*(4), 6549-6559. https://doi.org/10.3233/JIFS-224590.

[20] Ke, Y. (2023). Location and tracking mode of sports rehabilitation training with self-powered sensors based on particle swarm optimization algorithm. *IEEE Sensors Journal*, *23*(18), 20894-20903. https://doi.org/10.1109/JSEN.2023.3241269.

[21] Liu, J., Li, Y., Li, Y., Zibo, C., Lian, X., & Zhang, Y. (2022). Location optimization of emergency medical facilities for public health emergencies in megacities based on genetic algorithm. *Engineering, construction and architectural management*, *30*(8), 3330-3356. https://doi.org/10.1108/ECAM-07-2021-0637.

[22] Benelhouri, A., IDRISSI-SABA, H., & Antari, J. (2024). A Novel Hybrid Particle Swarm Optimization-Simulated Annealing Algorithm for Maximizing Coverage in IoT-Enabled Wireless Sensor Networks. https://doi.org/10.21203/rs.3.rs-5375381/v1.

[23] Cai, H., Tong, C., Li, Z., Guo, X., Shi, Y., Jiang, M., & Lin, B. (2024). Efficient particulate matter source localization in dynamic indoor environments: An experimental study by a multi-robot system. *Journal of Building Engineering*, *92*, 109712. https://doi.org/10.1016/j.jobe.2024.109712.

[24] Mohanaprakash, T. A., Kulandaivel, M., Rosaline, S., Reddy, P. N., Bhukya, S. N., Jogekar, R. N., & Vidhya, R. G. (2023). Detection of brain cancer through enhanced Particle Swarm Optimization in Artificial Intelligence approach. *Journal of Advanced Research in Applied Sciences and Engineering Technology*, *33*(2), 174-186. https://doi.org/10.37934/araset.33.2.174186.

[25] Candia, D. A., Játiva, P. P., Azurdia Meza, C., Sánchez, I., & Ijaz, M. (2024). Performance analysis of the particle swarm optimization algorithm in a vlc system for localization in hospital environments. *Applied sciences*, *14*(6), 2514. https://doi.org/10.3390/app14062514.

[26] Lakshmi, Y. V., Singh, P., Abouhawwash, M., Mahajan, S., Pandit, A. K., & Ahmed, A. B. (2022). Improved Chan algorithm based optimum UWB sensor node localization using hybrid particle swarm optimization. *IEEE Access*, *10*, 32546-32565. https://doi.org/10.1109/ACCESS.2022.3157719.

[27] Sun, D., Wei, E., Ma, Z., Wu, C., & Xu, S. (2021). Optimized cnns to indoor localization through ble sensors using improved pso. *Sensors*, *21*(6), 1995. https://doi.org/10.3390/s21061995.

[28] Nam, H., Nunes, M. G. V., & Loukachevitch, N. (2023). 3D printing: Next-generation realization for future applications. International Journal of Communication and Computer Technologies, 11(2), 19-24.

[29] Abdullah, D. (2024). Recent advancements in nanoengineering for biomedical applications: A comprehensive review. Innovative Reviews in Engineering and Science, 1(1), 1-5. https://doi.org/10.31838/INES/01.01.01.

[30] Zheng, J., Li, K., & Zhang, X. (2022). Wi-Fi fingerprint-based indoor localization method via standard particle swarm optimization. *Sensors*, *22*(13), 5051. https://doi.org/10.3390/s22135051.

[31] Zhang, C. Y., Wang, S. L., Yu, C. M., Xie, Y. X., & Fernandez, C. (2022). Improved particle swarm optimization-extreme learning machine modeling strategies for the accurate lithium-ion battery state of health estimation and high-adaptability remaining useful life prediction. *Journal of the Electrochemical Society*, *169*(8), 080520. https://doi.org/10.1149/1945-7111/ac8a1a.

[32] Dharani, R., Revathy, S., & Danesh, K. (2023). Fuzzy genetic particle swarm optimization convolution neural network based on oral cancer identification system. *J. Appl. Eng. Technol. Sci. JAETS*, *5*(1), 150-169. https://doi.org/10.37385/jaets.v5i1.2874.

[33] Faria, R. M., Rosa, S. D. S. R. F., Nunes, G. A. M. D. A., Santos, K. S., de Souza, R. P., Benavides, A. D. I., ... & González-Suárez, A. (2024). Particle swarm optimization solution for roll-off control in radiofrequency ablation of liver tumors: optimal search for PID controller tuning. *Plos one*, *19*(6), e0300445. https://doi.org/10.1371/journal.pone.0300445.

[34] Mandal, S., Ghosh, S., Jana, N. D., Chakraborty, S., & Mallik, S. (2024). Active Learning with Particle Swarm Optimization for Enhanced Skin Cancer Classification Utilizing Deep CNN Models. *Journal of Imaging Informatics in Medicine*, 1-18. https://doi.org/10.1007/s10278-024-01327-z.

[35] Ayman, A., Mohamed, H., Antoun, M., Mohamed, S. E., Amr, H., Talaat, Y., & Hassan, W. (2024, November). Optimized Deep Learning Models Using Particle Swarm Intelligence for MindMend, Stroke Rehabilitation System. In *2024 International Mobile, Intelligent, and Ubiquitous Computing Conference (MIUCC)* (pp. 76-83). IEEE. https://doi.org/10.1109/MIUCC62295.2024.10783610.

[36] Wang, Q., & Haga, Y. (2024, May). Research on Structure Optimization and Accuracy Improvement of Key Components of Medical Device Robot. In *2024 International Conference on Telecommunications and Power Electronics (TELEPE)* (pp. 809-813). IEEE. https://doi.org/10.1109/TELEPE64216.2024.00151.

[37] Mundada, M. R., Sowmya, B. J., Supreeth, S., Prabhu, S. G., Mahesh, K., Vishwanath, Y., & Rohith, S. (2024). Skin Cancer Prediction by Incorporating Bio-inspired Optimization in Deep Neural Network. *SN Computer Science*, *5*(8), 1127. https://doi.org/10.1007/s42979-024-03501-0.

[38] Myriam, H., Abdelhamid, A. A., El-Kenawy, E. S. M., Ibrahim, A., Eid, M. M., Jamjoom, M. M., & Khafaga, D. S. (2023). Advanced meta-heuristic algorithm based on Particle Swarm and Al-biruni Earth Radius optimization methods for oral cancer detection. *IEEE Access*, *11*, 23681-23700. https://doi.org/10.1109/ACCESS.2023.3253430.

[39] Taher, S. M. (2025). Application of Improved PSO in Augmented Reality for Dental Healthcare. *Journal of Advanced Research in Applied Sciences and Engineering Technology*, *50*(2), 90-102.

[40] Irshad, R. R., Sohail, S. S., Hussain, S., Madsen, D. Ø., Ahmed, M. A., Alattab, A. A., & Ahmed, A. A. A. (2023). A multi-objective bee foraging learning-based particle swarm optimization algorithm for enhancing the security of healthcare data in cloud system. *IEEE Access, 11*, 113410-113421. https://doi.org/10.1109/ACCESS.2023.3265954.

[41] Zarrouk, R., Mahmoudi, R., Bedoui, M. H., & Hu, Y. C. (2024). Home healthcare: particle swarm optimization for human resource planning under uncertainty. *Multimedia Tools and Applications*, 1-34. https://doi.org/10.1007/s11042-024-20168-0.

[42] Sio, A. (2025). Integration of embedded systems in healthcare monitoring: Challenges and opportunities. SCCTS Journal of Embedded Systems Design and Applications, 2(2), 9–20.

[43] Kavitha, M. (2024). Environmental monitoring using IoT-based wireless sensor networks: A case study. Journal of Wireless Sensor Networks and IoT, 1(1), 50-55. https://doi.org/10.31838/WSNIOT/01.01.08.

[44] Prasath, C. A. (2025). Green Hydrogen Production via Offshore Wind Electrolysis: Techno-Economic Perspectives. National Journal of Renewable Energy Systems and Innovation, 8-17.