International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 19s, 2025
https://theaspd.com/index.php

Enhance Rfid Network Planning By Combining Edge Detection With Pso Algorithm

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Abstract
One of the key factors influencing the degree of production performance in terms of both quantity and quality is the control of material flow during the assembly process in factories. We have conducted all of this research to examine the locations for gathering and producing materials, organizing their data, and feeding it into an algorithm to ascertain the quantity of readers and the scope of coverage because there is no automated system that provides us with the best locations for the material transfer process. This research delineates the outcomes of a multi-objective function model for the placement of RFID readers across several large-scale scenarios, intended to assess the implications of network expansion. Four distinct techniques were analyzed using the identical dataset. The dataset aimed to organize 60 tags inside the facility design based on a designated clustered distribution. Simulation results indicated that E-PSO outperformed other methods in tackling particular RNP issues, achieving significant tag coverage in reader deployment. The findings underscored the applicability and robustness of the proposed method, with its characteristics retaining exceptional approximation capabilities even in factory designs utilizing RFID systems.
Keywords: *RFID, PSO algorithm, Edge detection, Canny*

1. INTRODUCTION

In non-contact autonomous identification systems, an RFID tag is an electronic device. RFID devices communicate and supply energy to monitored items through the use of radio frequency (RF) signals [1]. RFID systems are composed of three primary components: middleware, readers, and tags. Frequently, the object that requires identification is equipped with a transponder. An antenna and a microprocessor, each with a distinct code, comprise this item identification. The interrogator or reader transmits radio signals to the tag. Typically, a reader comprises a control device, an antenna, a radio frequency module for signal transmission and reception, and a transmitter. The middleware is the third component, which facilitates the connection between databases and RFID scanners [2].
RFID devices are classified into two categories: active and passive. The cost of an active tag circuit is higher due to the necessity of a battery. It is ideal for the transportation of large commodities, such as port containers or parking lot automobiles, due to its processing capacity, which is concealed by its diminutive size. In contrast, a passive tag is cost-effective, lightweight, and compact, and may be powered by the radio frequency of the reader. The primary objective of RNP is to enhance the comprehensibility of tag coverage. RNP optimization can be achieved by determining the optimal placement and power level for each receiver. Consequently, a diverse array of algorithms were implemented to ascertain the optimal reading positions. [3]

2. RELATED WORKS

A intriguing new area of technological application has emerged, made possible in part by artificial intelligence (AI) approaches. When applied to various issues, optimization techniques provide a potent toolbox for discovering the best possible answers. With the RFID system's built-in optimization and search algorithms, problems including exploring badly ordered areas, dealing with growing complexity, and huge search spaces were effectively tackled. As a result, algorithms in this field are derived from those found in nature [4].
In 2008 and 2009, Karaboga put out the artificial bee colony algorithm (ABC), an optimization method inspired by the smart foraging actions of honey bee swarms. Comparing the ABC approach to other optimization strategies, it offers numerous advantages. [5][6]. Incorporate a novel method known as the Gbestguided ABC (GABC) algorithm into the ABC algorithm [7].[8]. Sequential, parallel, or multi-stage

emergence are the three possible forms of the ABC hybrid type. In the first, one algorithm optimizes globally while the other searches locally; in the second, they run in sequence until they both meet the convergence criterion. Solutions of a high standard are among the outcomes. [9]. When faced with complex design issues in RFID networks, an alternative optimization method is multi-colony bacteria foraging optimization (MC-BFO). This approach enhances the single-population bacterial foraging algorithms by relating the chemotactic behavior of individual bacterial cells to the interacting multi-colony model through bacterial cell-to-cell communication.10[11]. This is the procedure by which a bacteria finds a more suitable habitat and adjusts to it. When a bacterium's fitness stays the same regardless of its swimming distance, it will go into exploratory mode. [12]. Methods for optimizing populations include the Particle Swarm Optimization (PSO) algorithm. The method was built upon the well-documented patterns of collective migration observed in fish and birds. Fast operating speed, simple installation, and little parameter adjusting are just a few of PSO's many benefits when it comes to solving optimization challenges. [13]. One particle swarm optimizer that can handle multiple swarms is the MCPSO. When compared to regular PSO and its variations, the proposed algorithms perform better, with MCPSO coming out on top. cited as [14]. Algorithms like Evolutionary Algorithms (EAs) and Swarm Intelligence (SI) are highly effective for designing mathematical models. The most effective system was the RFID network that used Particle Swarm Optimization (PSO) in conjunction with reader placement. [15].Optimizing complicated RFID scanners in big systems is possible with Particle Swarm Optimization [16]. The method's utility is demonstrated by quantitative results. [17]. A new particle swarm optimization (PSO) method improves RFID network performance by identifying and removing readers during the PSO search phase and then recovering them. This method makes use of a tentative reader elimination (TRE) operator. You can change the amount of readers as needed. The suggested method may be able to cover more area with fewer readers than current algorithms, according to experimental data. The multi-community GA-PSO is an innovative optimization method proposed by Han in [18]. It made the formerly daunting process of creating an RFID network for a massive system much easier. The suggested approach enhances the performance of PSO and offers practical answers to the coverage issue by integrating genetic algorithms (GA) with PSO. The RNP problem was solved, along with all Pareto optimum solutions and optimal planning techniques, by employing swarm intelligence approaches and multiobjective evolutionary algorithms. The goal of MOPSO, or Multi-Objective Particle Swarm Optimization, is to accomplish multiple objectives at once by utilizing particle swarms. When it comes to constructing RFID networks, MOABC performs better than NSGA-II and MOPSO in terms of computation resilience and optimization accuracy, according to the simulation results.It is the year 19. By evaluating thirteen benchmark functions, the adaptive small-world topology demonstrated that the ASWPSO was efficient and durable [22]. To enhance the topology effect in multi-objective RFID network design, Elewe et al. (2017) integrated the firefly technique with the Density Based Clustering methodology (DBSCAN). A subpar algorithm was employed in an effort to maximize cost efficiency. Researchers found that RFID network planners faced significant obstacles when attempting to use the method in big, complicated facilities with varying configurations of internal workstations [23].

3. THE SYSTEM METHODOLOGY

The next section describes the present system methodology.

Step 1: facility layout design

The arrangement of machinery and equipment within a plant is determined by its design and layout. It also includes the structural planning of departments on the factory floor, the placement of devices within those divisions, and the arrangement of individual workstations. When planning equipment and machinery in a factory layout, it is critical to reduce internal transit and keep expenses as low as feasible [24].

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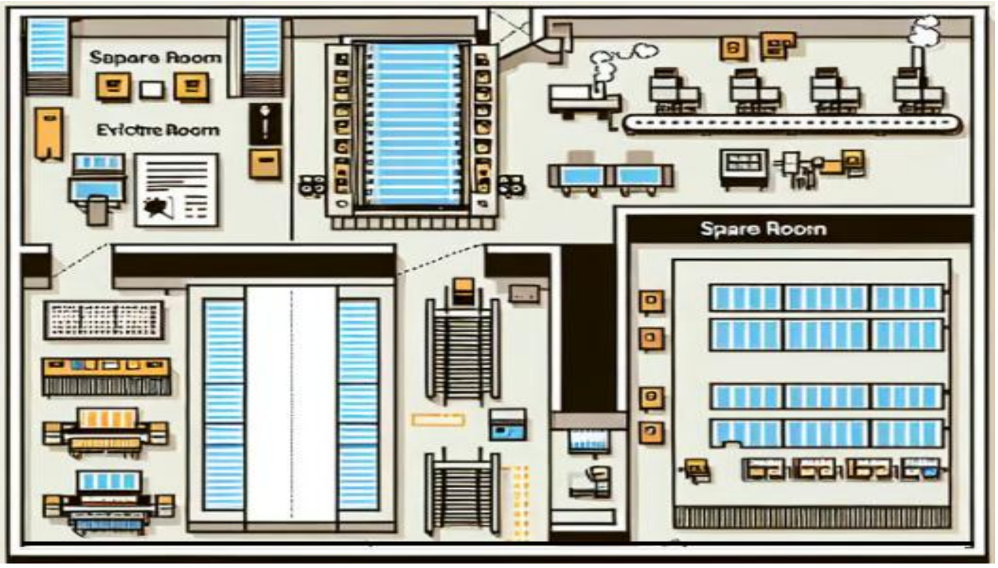

Figure 1: facility layout proposed design

Transportation can begin at any point in a factory's layout, which includes machines, worktables, and warehousing components. Consequently, the planner also has challenges when trying to determine the best layout, as he must easily incorporate hundreds of different transportation linkages into a comprehensive image. Material flow planning will subsequently address this. Aside from transportation, the space required for equipment and supplies is an important factor to consider when developing a layout. This is because it significantly affects the costs of the premises [25].

Step 2: developing tag coverage

The amount of communication between the reader and the tag, as well as the signal conveyed from the tag to the reader, are critical components of the tag coverage function. It is recommended to use the following goal function to decrease tag coverage:

$$C_{\min} = \sum_{i=1}^{Np} (P_i^r - P_d)$$

$$P_r = (P_r.G_t.P_r)/(4\pi \frac{d}{\lambda})^2$$

Step 3: Developing RFID System

In the RFID network planning (RNP) problem, each optimization approach has its own set of parameters that have been fine-tuned to improve performance. Parameter values [26] are identified in Table 1.

Table 1: RFID parameters[26]

Parameters	Values
RFID Reader System Operating Frequency	UHF band: 915 MHz
RFID Reader adjustable Transmitting power range	[20; 33]Dbm 0.1 to 2 watts
Sensitivity thresholds of tags Tt	-14 dBm
Sensitivity thresholds of Readers are dBm Tr	-70 dBm
RFID Reader Antenna Gain (Gr)	7.3 dBi
RFID Tag Antenna Gain (Gt)	3.7 dBi

Three formulas provide a concise summary of the objective functions. The first equation addresses the optimal tag coverage, or C. One remarkable feature is its ability to capture all tag IDs scattered around the region [27]. The computation entails computing the difference between the actual power received by each tag and the required power, given as:

$$C_{min} = \sum_{i=1}^{N_T} (P_{tagi} - P_{req})$$ Ptagi= Actual received power at each tag

Preq= Required threshold power
NT=Number of tags in working area

For each tag, the Friis transmission equation power is applied to find the power input at receiving antenna as shown below[26][28]:

$$P_r = (P_t . G_t . G_r) / (4\pi \frac{d}{\lambda})^2$$

$$\text{coverage} = \sum_{i=1}^{nt} [\, P_{reaer} + G_{tagi} + G_{reader} + 20\log\,\_10(\frac{0.026}{\sqrt{(x_i - a)^2 + (y_i - b_i)^2}} + 10])$$

Collisions resulting from reader interference can be mitigated by defining the interrogation ranges of the readers and controlling their emitted power. Interference is articulated as[26][28]:

$$\text{int.} = \sum_{i=1}^{N-1} \sum_{(j=i+1)}^{N_{max}} [d_t (R_i , R_j) - (r_i + r_j)\,] \qquad \backslash$$

Nmax denotes the maximum number of readers, "dt" represents the distance between readers, Ri indicates the position of the ith reader, Rj signifies the position of the jth reader, rj refers to the interrogation range of the jth reader, and ri pertains to the interrogation range of the ith reader.[26][28]:

Nreq = Nmax – Nextra

The current solution evaluates the ideal placement for each reader and several efficient readers. The current objective functions will be applied in both the firefly algorithm and MC-GPSO to determine the best level of network planning.

Step 4: Factory Design Edge Detection

Edge detection is a fundamental component of computer vision and image processing. It involves identifying and pinpointing sudden visual discontinuities, typically associated with significant variations in color or luminance. The composition and essence of an image can be comprehended by recognizing edges, which indicate discontinuities. Edge detection can identify the boundaries of objects in images. It enhances image data by reducing the volume of information requiring processing while preserving the image's structural characteristics. Object detection, segmentation, and picture enhancement exemplify image analysis activities necessitating this reduction. [28]. Edge detection techniques are typically classified into two categories: gradient-based methods and second-order derivative methods.

Edges are identified by gradient-based methods that analyze the maximum and minimum values of the image's first derivative. The gradient of an image illustrates the variation in luminance at a specific location. Roberts Cross, Sobel, and Prewitt are the foremost gradient-based operators. Moreover, methods for second-order derivatives identify zero crossings in the image's second derivative, facilitating edge detection. The Laplacian operator, a second-order differential operator, has various applications. It emphasizes border regions characterized by abrupt fluctuations in intensity. The multi-stage Canny edge detector seeks to effectively address edge detection challenges. It proceeds as follows: [29].

1. Initially, utilize a Gaussian filter to smooth the image and diminish noise.
2. Gradient Calculation: Employ techniques such as Prewitt or Sobel to ascertain the intensity gradients of the image.

3. Mitigating Gradients That Are Not Local Maxima: This approach diminishes edge thickness.
4. Double Lever Threshold: Employ threshold values to discern robust and feeble edges.
5. Hysteresis for Edge Tracking: Upon finalizing edge identification, link weak edges to strong edges if they constitute the same segment [30].

Step 5: developing PSO Algorithm

Kennedy and Eberhart argue that the Particle Swarm Optimization (PSO) algorithm is a flexible method based on social psychology similarities. It works by allowing a group of people, known as "particles," to return at random to places where they have previously succeeded. The technique is then repeated until the minimum number of errors is reached or a predetermined number of iterations have happened. The PSO algorithm relies on its implementation in the following two relationships [31][32][33]:

The velocity of particle i is updated using the following equation:

$v_{id}(t+1) = wv_{id}(t) + c_1r_1(t)(p_{id}(t) - x_{id}(t)) + c_2r_2(t)(p_{gd}(t) - x_{id}(t))$

$v_{id} \in (-V_{max}, +V_{max})$

The position of particle i, x_i is then updated using the following equation:

$x_{id}(t+1) = x_{id}(t) + v_{id}(t+1)$

RESULTS AND DISCUSSION

The basic problem that was addressed in this research is the process of determining specific locations for multiple components that are linked together to form a single product at different stages in a way that enables the factory management to monitor and control the transfer of materials between the factory units in order to prevent or ensure that those components are not lost and avoid the error of transferring a specific component to the wrong place in the factory parts. The first stage in choosing the location represents entering the design formula into the schematic program to determine the locations of the materials and allocating them. This is done after reading the image and determining the angles and frames for the work locations. In the second stage, the tags are deployed in its designated locations, and then the PSO is operated to place and determine the readers and the extent of coverage. The simulations were carried out, and the results were acquired using the methods provided in Figure 2. The number of tags utilized was 60. All discoveries created by the RFID network. It can be notice in the form of number two of the operation of the PSO algorithm directly on the facility design resulting in 3 readers completely surrounding the industrial components required to be monitored, where the industrial parts were designated in blue, which represent the assembly operations of multiple parts using the Kanban method and are completely subject to monitoring and control. This type of monitoring is used in sensitive laboratories and products that are encouraged to be assembled in isolated places.

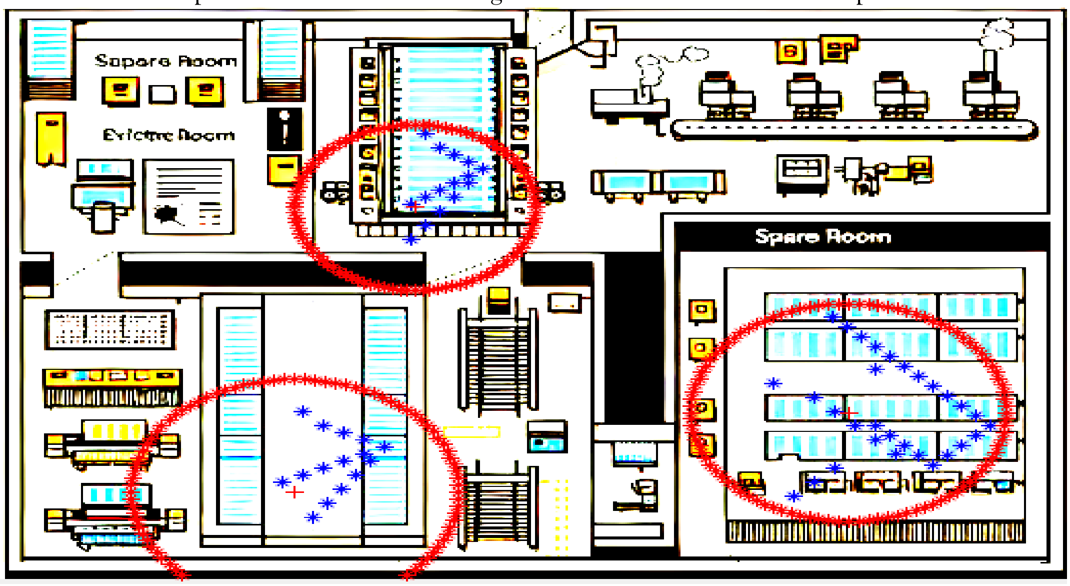

Figure 2: PSO results of small tags data in large area

The traditional procedure for selecting the location and distributing the tags depends on entering data manually, which is an inaccurate and time-consuming process. But due to the large number of details in the design plan, it causes inaccuracy in choosing places or the extent of coverage. Therefore, by applying the Edge detection canny method, the places where the parts and components of the product are assembled are separated, thus making it easier to control it and calculate the necessary coverage by the readers.

The algorithm determines the edges and corners of the product production halls and then determines the actual center of the hall on the basis of which the products are published and distributed, the algorithm automatically determines the locations of the tags products and, based on that, calculates the location of the reader and the extent of coverage. The results in Figure 3 to 5 below show the results.

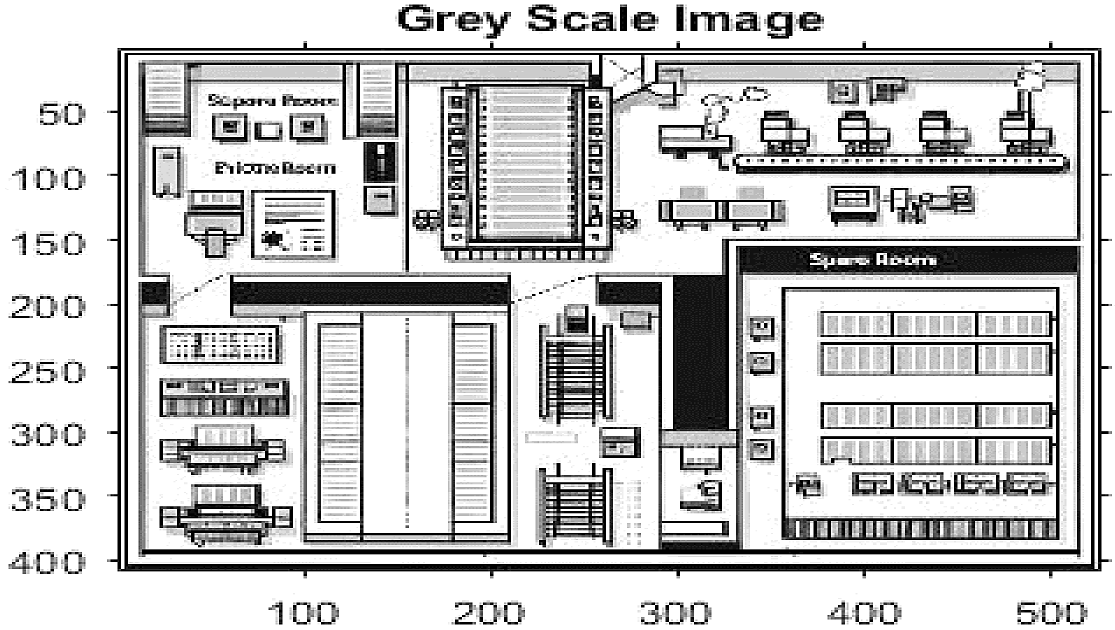

Figure 3: the first step is convert image to gray scale

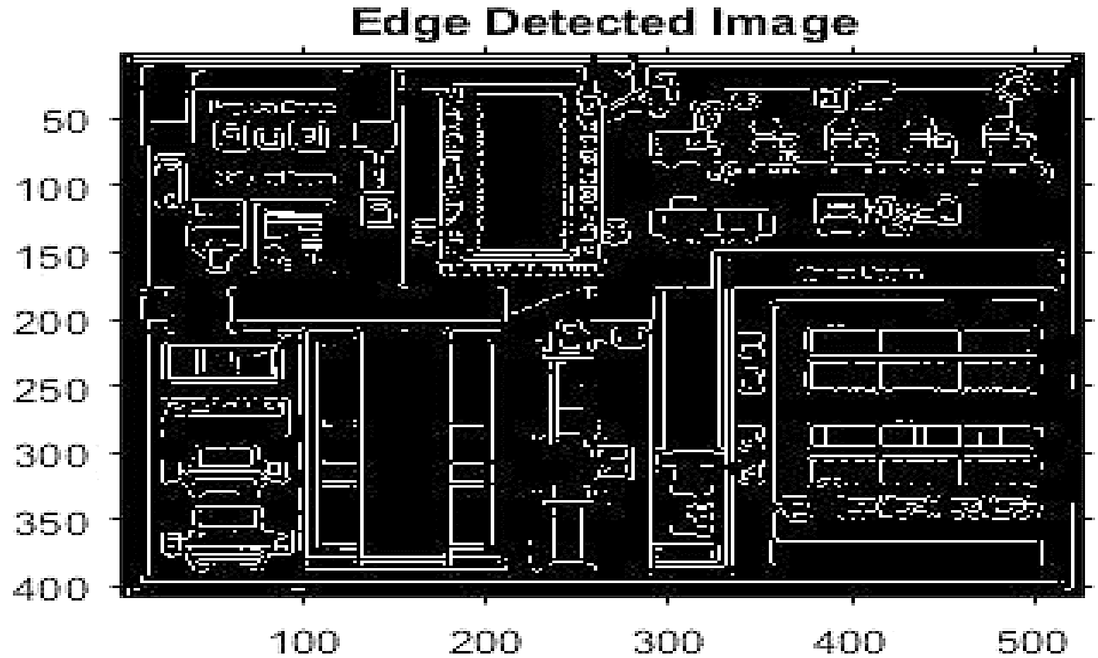

Figure 4: the second step detect the area edges of the factory departments

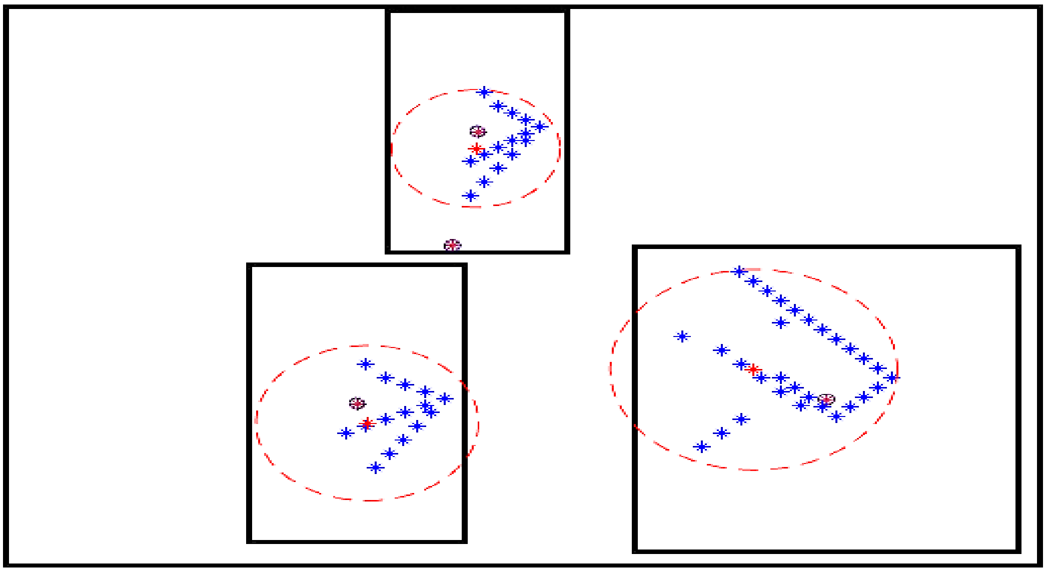

Figure 5: the final step apply the PSO algorithm to specify the readers

Two categories of network architecture instances are examined in this study: random (C60) and the outcome of 10,000 iterations across 50 distinct trials on MATLAB 2021. The blue plus sign represents the marks, while the red star in the center of the map represents the readers. Employing the red dashed line to define the scope of the inquiries. The data analysis revealed that the RFID readers were distributed into two zones, each of which had a unique probability of detecting and enclosing the tags. The results are summarized in "Table 2" below:

Table 2: simulation numerical results

algorithm	Tags Number	active readers	tags coverage	fitness	iteration
PSO	60	3	60	0.86	10000
E-PSO	60	3	60	0.91	2000

The findings indicated that the E-PSO algorithm exhibited the maximum performance level at 91%, successfully encompassing all tags regardless of the facility's distance and cluster distribution. These results are deemed adequate at first glance.

CONCLUSION:

Analyzing the most effective approach for large-scale applications network planning is crucial for the execution of RNPs in practical scenarios, such as the management of industrial processes through an RFID system. This was accomplished by first examining the algorithm's response to an increase in tags, subsequently doing thorough testing and comparison of edge recognition techniques. This study seeks to enhance the search algorithm when applied in an extraordinarily extensive domain. The optimal approach for recognizing a restricted number of tags was found to be PSO. However, the task of configuring a factory's design and optimizing industrial operations, including the transportation of materials between departments, is a significant barrier for the PSO algorithm, as it is unable to ascertain the appropriate locations for this configuration. This study aimed to connect the edge-determining approach to build a specialized operational mechanism for the division and management of product movement during the assembly process.Imaging and computer vision fundamentally rely on edge detection, which is associated with a wide range of applications. In applications requiring the comprehension and interpretation of visual data, edge detection is a crucial technique due to its ability to extract essential structural information. Consequently, technology progresses incrementally through the application of edge detection techniques. Benchmark testing indicates that E-PSO outperforms its competitors in convergence rate, processing time, and cost efficiency. The results indicate that the algorithm's efficacy is compromised due to the substantial difference in tag placements. A finite number of swarms can exist. The limitation is attributable to transfer constraints.

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