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Big Data Swarm Intelligence Optimization Algorithm Application in the Intelligent Management of an E-Commerce Logistics Warehouse

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ABSTRACT

A dynamic mutation probability formula is utilized to optimize the model. In order to solve the logistics warehouse path problem, the ant colony optimization algorithm, optimized by a genetic algorithm, is employed to construct a logistics warehouse path optimization model. This model effectively optimizes the logistics warehouse paths. Test results comparing the convergence and distribution of non-inferior solutions demonstrated that the proposed model outperforms others in terms of convergence and non-inferior solution distribution. In practical logistics warehouse optimization, applying the proposed model to optimize cargo locations can significantly enhance the effectiveness of the objective function. The optimization resulted in improvements for all four objective functions related to cargo location, with reduction rates of 10.38%, 30.88%, 51.78%, and 88.49%, respectively. For the optimization of logistics warehouse paths, the original distance was 47.6m, which was reduced to 27.8m after optimization. Consequently, the picking distance decreased by 41.60%.

KEYWORDS

E-commerce warehouse, Intelligent management, Path optimization, Particle Swarm Optimization, test

INTRODUCTION

According to available data, the e-commerce logistics industry has experienced significant growth in recent years. As of 2022, the global e-commerce logistics market reached a value of $3.51 trillion and is projected to continue growing steadily in the foreseeable future (Zhao et al., 2020). Traditional logistics systems are no longer capable of meeting the increasing demands of e-commerce logistics, particularly in terms of efficient goods planning and convenient accessibility. Moreover, traditional technologies face numerous challenges in equipment integration and optimizing goods management, resulting in operational issues such as slow delivery and inefficient warehouse paths (Pan et al., 2022). Furthermore, although traditional logistics management has become increasingly intelligent,

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there is still a lack of effective management and scheduling mechanisms, including path selection and space allocation, which significantly impact the management of logistics warehouse goods. To address these issues, a highly efficient logistics warehouse operation and management model based on big data technology is proposed. This model introduces an innovative population-based intelligent optimization model to achieve efficient management of logistics warehouse operations (Pu et al., 2022). Specifically, the proposed model presents a Multi-Objective Particle Swarm Optimization (MOPSO) approach for optimizing warehouse allocation, aiming to tackle the problem of slow cargo allocation within warehouses. Additionally, a dynamic mutation probability formula is introduced to optimize traditional models that frequently converge towards local optima. To enhance the efficiency of logistics warehouse paths, the study employs Ant Colony Optimization algorithms based on genetic algorithms (GA-ACO) to develop a logistics warehouse path optimization model, thereby achieving optimized logistics warehouse paths. The research content includes four parts. The first part introduces the current situation of e-commerce logistics warehouse management and the specific application of related technologies. At the same time, it studies and discusses the multi-objective optimization technology of e-commerce. The second part studies the e-commerce logistics warehouse system and related technologies, analyzes the optimization objectives of e-commerce management, and constructs two optimization models for e-commerce logistics warehouse management. The third part is to apply the mentioned technology to specific scenarios and verify the optimization effect of the proposed logistics warehouse management model in actual scenarios. The fourth part summarizes and analyzes the entire article, and elaborates on the improvement direction of the research.

RELATED WORKS

Warehouse management optimization is a key area of research within the e-commerce logistics industry, with a focus on optimizing picking paths and goods allocation, both of which are important objectives of intelligent warehouse management. Minashkina et al. (2023) researched existing logistics management systems, highlighting the current research focus on their implementation and layout. Intelligent e-commerce management systems play a crucial role in clarifying e-commerce operations and system interaction management, while digital technology provides essential technical support for effective management. By reviewing relevant literature and materials, this research contributes to the digital and intelligent development of logistics warehouses and helps determine their future direction. In their study, Hu et al. (2023) analyzed the growth of domestic e-commerce and its impact on the logistics industry. They recognized the significance of solving sorting efficiency issues in logistics warehouses and proposed a system layout scheme. To achieve this, they developed a nonlinear programming model for logistics warehouses, which was solved through functional objective relationships. Compared to traditional particle swarm optimization models, this scheme demonstrated superior convergence and significantly optimized costs after layout, leading to reduced operating costs and improved efficiency in logistics warehouse management. Sun et al. (2022) investigated order instructions in traditional logistics warehouses. In such settings, there tends to be a focus on the volume occupancy rate of goods, often overlooking human biases, which results in decreased efficiency in warehouse management. To address this issue and reduce warehouse management costs, the researchers introduced two optimization mechanisms. They proposed a human concept packing strategy and estimated human biases to mitigate these deviations in logistics warehouse management. Experimental results showed that this approach significantly enhanced the effectiveness of logistics warehouse management, reduced operating costs, and decreased average packaging time for target packages by 4.5%. Tufano et al. (2022) studied modern e-commerce logistics management systems, which generate substantial amounts of daily goods flow data, thereby imposing a significant burden on system operations. To reduce system energy consumption and enhance the efficiency of logistics warehouse management, the researchers introduced a training classifier to improve system performance. Through data training, this classifier effectively predicts warehouse system behavior