International Journal of Distributed Systems and Technologies
Volume 16 • Issue 1 • January-December 2025

Matching Community Sports Facilities With Ant Colony Algorithm in National Fitness

Peng Chen
Anyang University, China

Tian Tian
Hainan Tropical Ocean University, China

ABSTRACT

This study addresses the challenge of selecting optimal locations for urban sports facilities, leveraging the strengths of the ant colony optimization (ACO) algorithm. An enhanced ACO model is proposed, incorporating population density and distance to sports facilities as critical factors in the objective function. The model employs a unique pheromone updating strategy that reduces search time and improves solution quality. Two updates to the pheromone levels are performed, and the initial pheromone distribution is reset based on path distances. The effectiveness of the model is demonstrated through a case study in Yuhua District, Changsha City, where it successfully identifies prime locations for public sports facilities. This research contributes to the literature on facility siting and urban planning by offering a practical solution for optimizing the distribution of sports infrastructure within cities.

KEYWORDS

National Fitness Movement, Community Sports Facilities, Ant Colony Optimization (ACO), Urban Planning, Multi-Objective Optimization

INTRODUCTION

The National Fitness Movement has received increasing public attention. It is reported that China's 13th Five-Year Plan has created a favorable policy environment for national fitness, and the sports industry has achieved rapid development during this period (Liu et al., 2022). Local governments at all levels have responded positively to national policy requirements, actively invested resources in sports development, and comprehensively promoted the development of social enterprises and the construction of public service systems (Li et al., 2023; Li et al., 2018). As an important part of public services and social undertakings, sport has gained a wide space and opportunity for development during this period. Governments at all levels have not only deepened their understanding of the functions of sport but also increased their investment in sport development in terms of funds, talents and policies (Kidd, 2008). In addition, the Chinese People's Political Consultative Conference has issued a series of policy documents, laws, and regulations conducive to the regulation of sports, further strengthening the legal and institutional basis for sports reform in China (Wang & Ren, 2022).

In response to this trend, outdoor community sports facilities have emerged, accompanied by a proliferation of sports and fitness equipment, stadiums, and recreational and fitness integration facilities. This developmenthas given rise to a modern version of the National Fitness Movement primarily characterized by community sports (Greenwell et al., 2024). From the perspective of

DOI: 10.4018/IJDST.369653

individual sports or the importance of sports generally at the national level, there is a clear need to actively strengthen sports infrastructure, vigorously develop the system of sports facilities, create a conducive atmosphere for national fitness, and establish a robust hardware and software environment for the advancement of sports. This is a common demand of the current society, as evidenced by the findings of Erturan-Ogut and Kula (2023) and Zhang et al. (2023).

In recent years, research on facility placement has primarily concentrated on heuristic algorithms with evolutionary characteristics, particularly genetic algorithms, simulated annealing, ant colony optimization (ACO), and other algorithmic models (Amin-Tahmasbi et al., 2023; Korupolu et al., 2000; Shen et al., 2011). Heuristic algorithms can be guided by heuristic functions to achieve a near-optimal solution. Among the various heuristic algorithms, the ant colony algorithm (ACA) model is notable for its self-organization, robustness, positive feedback mechanism, and distributed computation, which have attracted increasing attention from scholars (Ali & Belal, 2007; Estrada-Jimenez et al., 2023).

Considering these issues, this paper seeks to integrate the theory of the ACA and propose an enhanced intelligent ant colony algorithm model. The objective function for the location selection of urban sports facilities was designed based on two key factors: population density and the distance of sports facilities. Concurrently, an optimization model for the location of urban sports facilities was developed. The model resets the distribution of the initial pheromone through the path distance, thus enabling the entire ant colony to search in a single direction, thereby reducing the search time of the model. Concurrently, the pheromone is updated and volatilized on two occasions. The model was implemented for the purpose of identifying optimal locations for public sports facilities in Yuhua District, Changsha City and yielded superior results.

LITERATURE REVIEW

The use of Ant Colony Algorithms (ACAs) in the optimization of community sports facilities has emerged as a significant topic of interest in recent literature. Zhang et al. (2021) proposed a vector pheromone routing method based on the priority Pareto partial order relation to improve evacuation efficiency in sports venues. This approach leverages the principles of ACO to enhance the safety and efficiency of crowd movements during emergency evacuations, ensuring that community sports facilities are safer and more responsive to potential emergencies.

Wu (2021) introduced the ACA to analyze sports fitness demands and explore the lack of sports facilities in urban areas. By applying this algorithm, Wu was able to identify patterns and gaps in the distribution of sports facilities, allowing for more targeted planning and development of new facilities. This research highlights the potential of ACAs in addressing the uneven distribution of sports resources and improving access to fitness opportunities in urban environments.

The study by the Fortified Optimization for Reliable Technology Systems - Ant Colony Optimization General Optimization Framework focused on the optimization of community sports facility configuration using the ACA. This framework aimed to optimize the layout and design of sports facilities to maximize their utility and efficiency (Golding et al., 2017). The authors demonstrated that the ACA could be effectively used to determine the optimal placement and size of various sports amenities, taking into account factors such as population density, usage patterns, and spatial constraints. This approach ensures that community sports facilities are designed to meet the specific needs of their users and the surrounding communities.

Yue and Dai (2022) investigated the collocation of community sports facilities in a national fitness environment based on the ACA. This study addressed the challenge of integrating multiple sports facilities within a single location to create comprehensive fitness hubs. Yue and Dai's (2022) research showed that by using the ACA, planners could efficiently determine the best combination and arrangement of different sports facilities, thereby enhancing the overall user experience and maximizing the utilization of available space.