Railway Container Transportation Service Network Design Optimization Model and Algorithm

Lixin Hou
Inner Mongolian Hohhot Vocational College, 010010, China

Keywords: Back Propagation Theory, Neural Network Algorithms, Network Design Optimization, Railway, Container, Transportation Services.

Abstract: Network design optimization plays an important role in intelligent railway container transportation services, but there is a problem of inaccurate design optimization. The traditional particle swarm algorithm cannot solve the network design problem in intelligent railway container transportation service, and the effect is not satisfactory. In today's fast-paced global economy, the efficient movement of goods has become a critical aspect of business operations. The optimization of railway container transportation networks is a crucial element in ensuring that goods are moved efficiently, cost-effectively, and reliably. To achieve these goals, the development of an effective optimization model and algorithm is necessary. In this article, we will discuss the key components of designing an optimal railway container transportation service network model and the corresponding algorithm to ensure efficient and reliable transportation services.

1 INTRODUCTION

NeThe primary objective of the railway container transportation service network optimization model is to minimize overall transportation costs while maintaining or improving service levels (Jiang and Li, 2020). The model should consider various factors, such as the location of origins and destinations, container capacities, train schedules, and route selection (Lan, 2022). Additionally, it should account for constraints such as handling times at terminals, train capacities, and available resources (Wang and Luo. 2022).

2 RELATED CONCEPTS

2.1 Mathematical Description of the Neural Network Algorithm

The neural network algorithm uses computer technology to optimize the network design optimization scheme, and according to the index parameters in the network design optimization, the unqualified value parameters in the network design optimization is found (Zhang and Yao, et al. 2022), and the network design optimization scheme is y_i integrated with the function to finally judge the feasibility of network design optimization, and the calculation is z_i shown in Equation (1).

$$\lim_{x\to\infty}(y_i \cdot t_{ij}) = \mathsf{SA} y_{ij} \geq \max(t_{ij} \div 2) \tag{1}$$

Among them, the judgment of outliers is $tol(y_i \cdot t_{ij})$ shown in Equation (2).

$$\max(t_{ij}) = \partial(t_{ij}{}^2 + 2 \cdot t_{ij}) \succ \mathrm{K}(\sum t_{ij} + 4) \tag{2}$$

An effective optimization model should also incorporate the concept of multimodal transport, whereby containers can be transferred between different modes of transportation (e.g., trucks, ships, and trains) at intermodal terminals (Cheng and Xue, 2022). This approach can help reduce transportation costs and increase the flexibility of the overall transportation network.

$$F(d_i) = \square \prod \sum t_i \bigcap \xi \cdot \sqrt{2} \rightarrow \oint y_i \cdot 7 \tag{3}$$

Hou, L.
Railway Container Transportation Service Network Design Optimization Model and Algorithm.
DOI: 10.5220/0013545000004664

In *Proceedings of the 3rd International Conference on Futuristic Technology (INCOFT 2025) - Volume 1*, pages 430-434
ISBN: 978-989-758-763-4

2.2 Selection of Network Design Optimization Scheme

The first step in applying a GA to the railway container transportation service network optimization model is to define the chromosome representation.

$$g(t_i)=\ddot{x}\cdot z_i\prod F(d_i)\frac{dy}{dx}-w_i\frac{n!}{r!(n-r)!} \tag{4}$$

To optimize the railway container transportation service network model, a suitable algorithm must be employed.

$$\lim_{x\to\infty} g(t_i)+F(d_i)\le\bigcap\ \max(t_{ij}) \tag{5}$$

A genetic algorithm (GA) can be utilized for this purpose, as it is particularly well-suited for solving complex optimization problems.

$$\sqrt{a^2+b^2}\,g(t_i)+F(d_i)\leftrightarrow mean(\sum t_{ij}+ \tag{6}$$

2.3 Analysis of Network Design Optimization Scheme

GAs are based on the principles of natural evolution, where solutions evolve through a process of selection, crossover, and mutation (Xu and Tang, et al. 2023). In the context of railway container transportation network optimization, GAs can generate multiple feasible solutions that can be evaluated and selected based on their fitness level (i.e., minimizing transportation costs and maximizing service levels).

$$No(t_i)=\frac{g(t_i)+F(d_i)}{mean(\sum t_{ij}+4)} \tag{7}$$

y repeatedly applying the selection, crossover, and mutation processes, the GA can generate a new population of chromosomes with improved fitness levels. This iterative process continues until a stopping criterion is met (e.g., a predetermined number of generations or a satisfactory solution).

$$Zh(t_i)=\bigcap\ [\sum g(t_i)+F(d_i)] \tag{8}$$

In conclusion, the design and optimization of railway container transportation service networks play a vital role in ensuring efficient and reliable movement of goods (Yang and Jin, 2022). By employing an effective optimization model and algorithm.

$$accur(t_i)=\frac{\min[\sum g(t_i)+F(d_i)]}{\mathrm{M}\sum g(t_i)+F(d_i)}\times 100\% \tag{9}$$

Each chromosome represents a potential solution, consisting of a sequence of genes that correspond to specific decision variables (e.g., container allocation and route selection). The initial population of chromosomes can be generated randomly or by using heuristic approaches (Wang and Wang, et al. 2023).

$$accur(t_i)=\frac{\min[\sum g(t_i)+F(d_i)]}{\sum g(t_i)+F(d_i)}+randon(t_i) \tag{10}$$

Subsequently, the fitness function must be defined to evaluate the quality of each chromosome. The fitness function should consider both transportation costs and service levels, with higher weights assigned to service levels if they are deemed more important than costs (Zhong and Kong, et al. 2022). The selection process can then be applied to choose the fittest chromosomes for reproduction, which involves generating new offspring through crossover and mutation operations (Tang and Dai, et al. 2022).

3 OPTIMIZATION STRATEGY FOR NETWORK DESIGN OPTIMIZATION

Crossover entails combining the genetic information of two parent chromosomes to create new offspring. Mutation introduces random changes in the chromosome representation to maintain diversity within the population and avoid converging too quickly on suboptimal solutions (He and Guo, et al. 2022).

4 PRACTICAL EXAMPLES OF NETWORK DESIGN OPTIMIZATION

4.1 Introduction to Network Design Optimization

In conclusion, the design and optimization of railway container transportation service networks play a vital role in ensuring efficient and reliable movement of goods. By employing an effective optimization model and algorithm.

Table 1: Network design optimization requirements

Scope of application	Grade	Accuracy	Network design optimization
Railway logistics and transportation	I	85.00	78.86
	II	81.97	78.45
Transportation service level optimization	I	83.81	81.31
	II	83.34	78.19
Transportation costs is minimized	I	79.56	81.99
	II	79.10	80.11

The network design optimization process in Table 1 is shown in Figure 1.

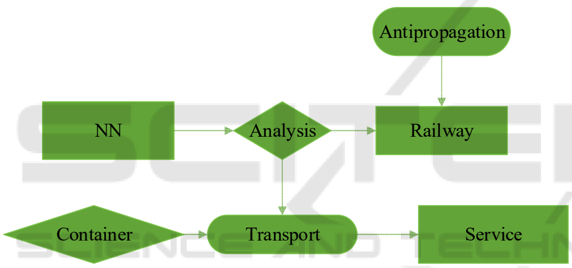

Figure 1: Analysis process for network design optimization

The backbone of global trade, logistics and transportation networks play a critical role in the efficient movement of goods. As an integral part of this network, rail container transportation services provide an essential link for intermodal transport. With the growing demand for sustainable and efficient transport solutions, optimizing the design of these service networks has become paramount. In this article, we will delve into the realm of optimization models and algorithms designed to improve the efficacy of the railway container transportation service network.

4.2 Network Design Optimization

The primary objective of these optimization models lies in achieving a balanced trade-off between service quality and operational cost. To attain this equilibrium, a thorough understanding of the existing network's architecture, including its nodes (railway stations), links (rail routes), and the dynamics of container flow, is crucial. The complexity inherent in these networks necessitates advanced mathematical models that can accurately capture their multifaceted nature.

Table 2: The overall picture of the network design optimization scheme

Category	Random data	Reliability	Analysis rate
Railway logistics and transportation	85.32	85.90	83.95
Transportation service level optimization	86.36	82.51	84.29
Transportation costs is minimized	84.16	84.92	83.68
mean	86.84	84.85	84.40
X6	83.04	86.03	84.32
		P=1.249	

4.3 Network Design Optimization and Stability

For instance, a linear programming model might seek to minimize the overall travel time of containers while ensuring fair distribution among different rail paths to avoid congestions. On the other hand.

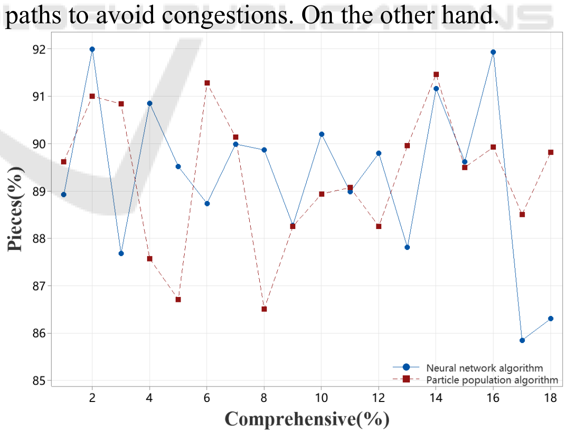

Figure 2: Network design optimization of different algorithms

An integer programming model could focus on selecting the most economical set of routes for specific container types under given time windows.

Table 3: Comparison of network design optimization accuracy of different methods

Algorithm	Survey data	Network design optimization	Magnitude of change	Error
Neural network algorithms	85.33	85.15	82.88	84.95
Particle swarm arithmetic	85.20	83.41	86.01	85.75
P	87.17	87.62	84.48	86.97

One approach to enhancing these networks is through the development of a robust optimization framework that employs linear programming, integer programming, or even mixed-integer linear programming methods. These techniques allow for the formulation of objective functions aimed at maximizing service reliability or minimizing total costs, subject to various constraints such as capacity limits, route selection, and handling times.

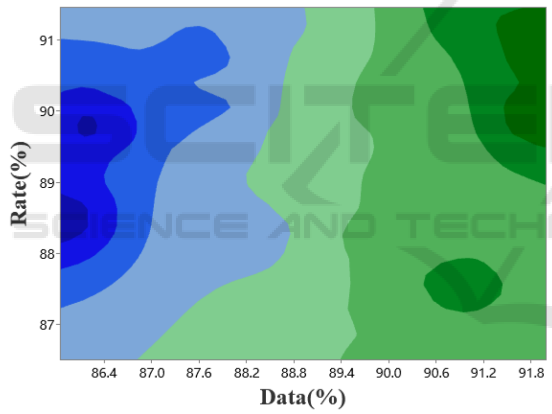

Figure 3: Network design optimization of neural network algorithms

Incorporating heuristic and metaheuristic algorithms further enhances the search efficiency for optimal or near-optimal solutions within vast solution spaces. Genetic algorithms, simulated annealing, tabu search, and ant colony optimization have been utilized to great effect in finding robust solutions to complex network design problems in container transportation.

4.4 Rationality of Network Design Optimization

To verify the accuracy of the neural network algorithm, the network design optimization scheme is comprised with the particle swarm algorithm, and the network design optimization scheme is shown in Figure 4.

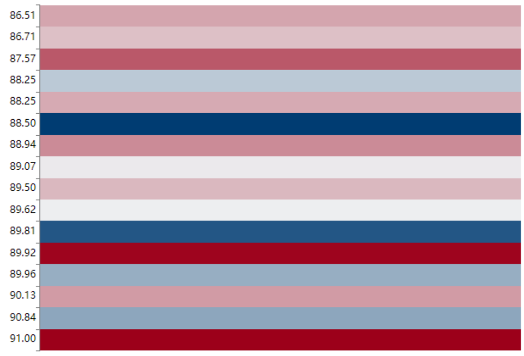

Figure 4: Network design optimization of different algorithms

Incorporating heuristic and metaheuristic algorithms further enhances the search efficiency for optimal or near-optimal solutions within vast solution spaces. Genetic algorithms, simulated annealing, tabu search, and ant colony optimization have been utilized to great effect in finding robust solutions to complex network design problems in container transportation.

4.5 The Effectiveness of Network Design Optimization

Apart from the direct benefits to the railway companies and service providers, these optimizations also contribute positively towards environmental conservation. By reducing unnecessary journeys.

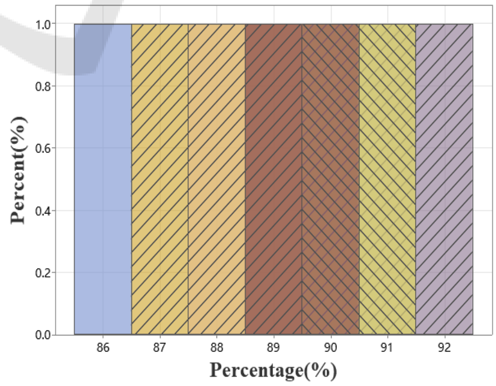

Figure 5: Network design optimization with different algorithms

Optimizing cargo loads, and improving the utilization of resources, carbon emissions associated with rail transport can be substantially curtailed.

Table 4: Comparison of the effectiveness of network design optimization of different methods

Algorithm	Survey data	Network design optimization	Magnitude of change	Error
Neural network algorithms	82.21	85.92	84.59	82.85
Particle swarm arithmetic	83.73	84.23	84.41	83.55
P	84.20	87.39	84.76	83.90

In conclusion, the design and operation of a highly optimized rail container transportation service network are pivotal for sustaining competitive advantage in the fast-paced world of logistics. Through the implementation of sophisticated optimization models and algorithms, it is possible to achieve substantial improvements in efficiency.

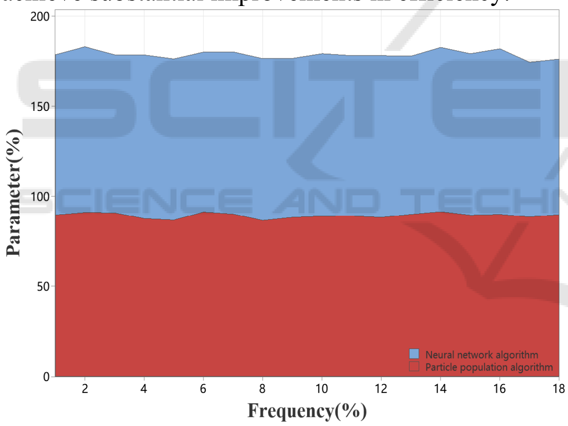

Figure 6: Network design optimization of neural network algorithm

Cost-effectiveness, and environmental performance. As the push towards smarter logistics solutions continues, leveraging these tools will remain crucial for any entity looking to navigate and thrive within the complex landscape of railway container transportation services.

5 CONCLUSIONS

By adhering to a continuous cycle of evaluation, optimization, and adaptation, the rail container transportation networks of today will undoubtedly evolve into the streamlined and efficient systems of tomorrow. This commitment to optimization ensures that the rails will continue to play a vital role in moving the world's commodities safely, reliably, and sustainably for many years to come.

REFERENCES

Jiang Yuxing, Li Hebi. (2020). Optimization model and algorithm for design of railway container transportation service network. Journal of Lanzhou Jiaotong University, 39(5), 10.

Lan Zekang. (2022). Optimization research on dynamic service network design of railway container transportation considering turnover of transportation resources. (Doctoral dissertation, Beijing Jiaotong University).

Wang Jisheng, & Luo Zhiyong. (2022). Dispatch optimization of container drayage transportation tasks based on heuristic algorithms. Manufacturing Automation, 44(1), 202-205.

Zhang Yinggui, Yao Yinghua, Gao Quanlei, Ding You. (2022). Optimization model and algorithm for balanced loading layout of mixed cargo in railway containers. Transportation Systems Engineering and Information, 22(2), 214-222.

Cheng Lu, & Xue Yuxi. (2022). Optimization of "door-to-door" transportation and delivery processes for railway containers based on Petri nets. (2).

Xu Bobing, Tang Canxuan, & Li Junjun. (2023). Robustness analysis of sea-harbor container transportation network under cascading failures. Transportation Systems Engineering and Information.

Yang Bowen, & Jin Zheyu. (2022). Research on optimization model and algorithm for high-speed railway express city distribution. Railway Freight Transport, 40(6), 6.

Wang Kun, Wang Haifeng, & Chai Ming. (2023). Optimization model and algorithm for route allocation in railway station operations. Railway Standard Design.

Zhong Zhaolin, Kong Shan, Zhang Jihui, & Guo Yiyun. (2022). Integrated optimization research on equipment configuration and operation scheduling of container terminal. Computer Engineering and Applications, 58(10), 263-275.

Tang Yinying, Dai Weidong, & Peng Qiyuan. (2022). Optimization method for China-Europe container transportation scheme based on multi-commodity flow. CN202010157633.9.

He Xun, Guo Peng, & Luan Yulin. (2022). Optimization of synchronizing transport and operation scheduling for container block trains based on breakthrough local search. Journal of Computer Systems & Applications(10).