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Research on Optimization of container Delivery Truck Appointment Considering No-showing and Carbon Emission

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Abstract: The truck appointment system is to set the share of truck appointment according to service capacity of the terminal gate and yard bridge, so that the facilities and equipment of container terminal can be reasonably used; On this basis, considering the situation that there are no-shows in container truck delivery process, and analyzing the impact of different types of no-shows on the appointment system. With the goal of minimizing the system cost of container terminal losses, an overbooking appointment model based on the optimization of container truck appointment is constructed by queuing theory, and the no-show probability is considered to optimize the original appointment share. Then designing an adaptive genetic algorithm to solve the model and search for the optimal overbooking scheme. Finally, an actual data example is used to verify the validity of the model and algorithm, which proves that the overbooking appointment model of the truck can more effectively improve the utilization rate of the terminal's equipment resources, reduce the terminal's meaningless carbon emissions, and restrict the irregular arrival of truck.

Keywords: queueing theory, disappointment, carbon emission, overbooking, adaptive genetic algorithm

1. Introduction

1.1. Background

With the fast development of global economic integration, trade and goods flows between countries and regions in the world are becoming more frequent. Among them, the rapid growth of international trade volume and the development trend of container transport have led to the sharp expansion of maritime trade volume, which puts forward higher requirements for the efficiency and service capacity of port terminals and brings many challenges to their operation.

At present, about 90% of container land transportation tasks rely on container trucks. However, during the process of delivering containers to the terminal, a large number of container trucks arrive at the terminal during the peak hours, resulting in disorderly management. On the one hand, the queuing time of container trucks at the port terminal is extended, and on the other hand, the terminal facilities and equipment are operating at close to or even full load; In low-peak hours, the idling of terminal facilities and equipment will also cause a waste of resources and increase the carbon emissions of port terminals.

In view of the above problems, under the coordination and cooperation with the local government departments, the container companies and container terminals found that the scientific setting of the container booking system can restrict the irregular arrival of the container trucks in different periods of time. The terminal shall set the number of container trucks that can be accepted by the system in different time periods, and the container trucks shall select the appropriate time window with service slots to deliver container according to the appointment information distributed by the terminal. However, in the actual port gathering process, due to some uncertain factors, such as weather, traffic conditions, human factors, etc., especially since the outbreak of COVID-19 in 2020, the truck drivers were forced to cancel the booking delivery plan be-cause of the epidemic. The truck could not arrive on time, and the booking system could not work effectively. The collection truck reservation system will be virtually non-existent without measures which could take to restrain the failure of the collection truck.

1.2. Literature Review

In recent years, many articles have carried out the research on how to improve the efficiency of container gate-in by container trucks. At present, As far as appointment of container truck is concerned, scholars have a deep understanding. Phan and Kim (2016)[1] proposed to the optimal scheduling plan of the container truck and the expected arrival quantity of the container truck at each appointment time by considering the container truck company and the terminal operator at the same time. Zeng Qingcheng et al. (2016)[2] used the vacation queuing model to describe the characteristics of the internal and external container trucks in the terminal, and built an optimization model for the container truck appointment that both of them jointly accept the terminal system services. Fan Houming et al. (2018) [3] studied the scheduling problem of container truck sending on the situation when a single off-port storage yard serves multiple terminals, and took carbon emissions into consideration of container truck booking. Ma Mengzhi et al. (2018) [4] found that the booking of container truck delivery can be cooperatively optimized with field bridge scheduling through the constructed two-layer programming model. Both Torkjazi et al. (2018) [5] and Ding Yi et al. (2020) [6] aim at reducing the gap between the actual arrival time of container truck and the original schedule. The former aims to minimize the cost of the container truck, while the latter can achieve a win-win for both the container truck company and the terminal operator. Guo Zhenfeng (2020) [7] set idle waiting energy consumption and moving energy consumption as optimization targets in the multi-terminal scheduling problem of container collection truck.

There is also some research support for the absence of appointments in the operation of the system. Zacharias and Pinedo (2017) [8] propose an optimal patient assignment scheme based on an overbooking strategy and a multi-help desk system for patient no-show behavior. Yang Hualong (2017) [9] conducted interference identification with the goal of minimizing the cost variation caused by interference events affecting the Zhang Wensi et al. (2019) [10] considered the ordering scheme for patients under two conditions, overbooking and non-overbooking, according to both the difference of service time that patients could receive and the behavior of no-show. Li Xiaohong et al. (2021) [11] considered the possibility of the goods not arriving as planned and established a two-stage model to determine the overbooked volume and allocate shipping space based on the overbooked strategy.

However, at present, there are few studies on the consideration of no-show in the reserved collection ports. Li et al. (2016) [12] only discussed processing methods of container trucks' no-show in a certain peiod of time. Liang Chengji et al. (2018) [13] took into account the possibility of emergencies at container terminals in each time window by using the rolling window technology. Yin Yandong et al. (2021) [14] hope to respond to no-show as soon as possible, aiming at the optimal number of overturning boxes and moving distance of field bridges.

To sum up, in the existing studies, most scholars only consider the smooth appointment of the container delivery by the container truck, without considering the interference behavior of no-show. The collection truck can not always arrive at the port on time all after the appointment, and the optimization effect is not ide-al. But the no-show of the container truck is objective, especially in the past two years under the influence of the epidemic, increased the uncertainty for the container delivery plan. Therefore this paper draws on the idea of overbooking of airline tickets to optimize the appointment share to reduce the frequency of no-show. At the same time, redefines the calculation of port carbon emissions. Taking the minimum unnecessary carbon emissions generated in the process of port col-lection as the goal, the queuing theory was used to build an overbooking appointment optimization model for the container truck, so as to make plans in advance for no-show, reduce the excess carbon emissions in the process of container delivery by container truck.

2. The Problem Description

2.1. The Problem Proposing

As shown in Figure 1, the container terminal establishes the container truck booking system, divides a day into appointment time window according to the terminal's operation, equipment utilization, and historical data of no-show, and sets the overbooking appointment share for each time window, and then publishes information on the online booking platform. The truck companies can through the telephone or online platform to select the appropriate time window for booking, each window on a first-come, first-served basis. When the share in time window has reached the maximum appointment amount provided by system, the system will reject the truck driver's application. The truck driver can only choose other time periods to make appointment. During the appointment stage, the driver can cancel the appointment plan at any time.

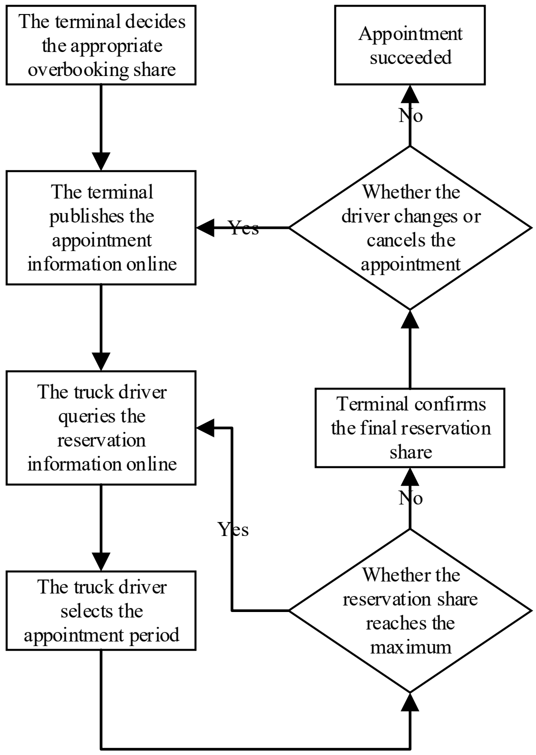

Figure 1. Appointment process of container truck

The process of container delivery by the container truck entering the dock is shown in Figure 2: The container truck arrives at the dock, if the gate has been occupied by other trucks, the arriving truck will queue up in the rear. Then the truck enter the gate to receive service. The gate channel is responsible for receiving relevant documents information of containers, input-ting them into the online system, and printing the receipt of the container truck; the driver arrives at the specially set waiting area of the yard with the receipt and waits for the service of the yard bridge. After the service, the container truck drive to leave the dock through the exit gate. The whole queuing process is composed of several independent M/M/1 queuing system at the dock gate and the queuing system obeying M/G/1 rules in the yard. The non-stationary secondary queuing network model is established by using queuing theory knowledge and PSFFA method.

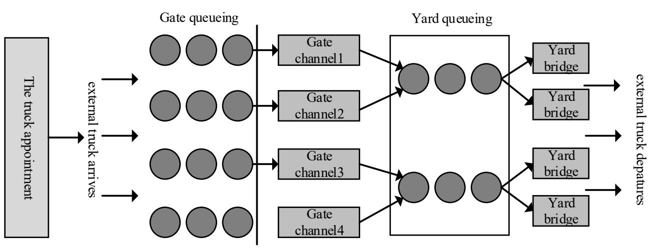

Figure 2. Collection process of external truck in container terminal

In the actual port collection process, the random occurrence of trucks' no-show caused the original port collection plan to be affected, which not only reduces the effectiveness of the truck's arrival rule constraint by the appointment system and cannot guarantee the smooth implementation of the appointment mechanism, but also affects the working efficiency of other trucks abiding by the appointment rules and the whole port. There are three kinds of no-shows: early arrival, late arrival and absence; The collection truck of early arrival can stop and turn off until the scheduled time to receive service, during the period, there is no excess carbon emissions will be generated; The late collection truck will disrupt the original appointment plan. Ac-cording to the system evaluation, the late collection truck will be automatically arranged to the next time window with free service time and equipment within the same day. The terminal operator will not bear the loss caused by this behavior to the truck. Finally, ab-sent container trucks will cause a certain waste of re-sources to the calculated system capacity and utilization, and increase unnecessary carbon emissions.

This paper mainly considers the absent behavior of trucks. In view of this behavior, this paper draws on the idea of air ticket overbooking in revenue management, and considers the actual arrival rate and unnecessary carbon emission of the container truck when the terminal determines the appointment share corresponding to the booking period, so that the actual arrival of the container truck can be infinitely close to the system capacity, and the terminal equipment utilization rate is maximum while the carbon emission cost of loss is minimum.

2.2. The Cost of Carbon Emission

A large amount of carbon emissions will be generated in the process of port collection by the container trucks. In the past published literature[15], the distance of transportation movement and no-load coefficient are generally used to calculate the energy consumption:

Horizontal transportation machinery: mainly responsible for the ground transportation of containers in the port area. The operation process of external container trucks in the port area is to enter the port gate and load containers before leaving the port gate.

Energy consumption of horizontal transport machinery=distance traveled by horizontal machinery ÷ travel speed × fuel consumption rate under full load and no load;

Site handling machinery: the site handling machinery is mainly responsible for the transfer of containers between the fixed position of the storage yard and the horizontal transport machinery. Taking RTG stacking containers as an example, its' operations mainly include lifting containers from horizontal transport machinery, crane traveling, trolley traveling, container stacking, lifting, and returning to the original place.

Energy consumption of loading and unloading machinery at the site=horizontal moving distance of equipment and vertical rising and falling height ÷ moving and lifting speed × power of field bridge in operation coefficient of no-load return coefficient to be considered.

Although the above energy calculation method scientifically covers the energy consumption in the process of collecting trucks, whether it is transportation or loading and unloading, this part is the consumption that would have generated in the process of ports collection.

Therefore, this paper first divides carbon emissions into necessary carbon emissions and unnecessary carbon emissions. The necessary carbon emissions will be generated in any case, like the transportation of container trucks and gantry cranes, docking of ships, which are indispensable; unnecessary carbon emissions can be understood as excess carbon emissions, which can be reduced or even avoided through reasonable operation. The objective of this paper is to study the unnecessary carbon emissions, which are divided into two parts in the process of booking the port. The first part is the carbon emissions generated by the truck waiting for service in the process of queuing at the gate and the yard, and the engine idling. The idling of the vehicle consumes more fuel than normal driving, and the higher the displacement, the more fuel it consumes per hour. Idle carbon emissions are related to the waiting time of the truck. Reducing the queuing time of the truck is equivalent to reducing the time of the truck in idle state, and the carbon emissions produced will also be reduced. Another part is due to the irregular arrival of the truck. In some periods of time, in order to serve the arriving truck at any time, the yard bridge is idling for some time. The state of loading and unloading and moving operation when the bridge is running is called dynamic state, and the state that loading and unloading does not occur, but consumes the quayside power is called static state, namely idling, which will also increase unnecessary carbon emissions. The calculation method of energy consumption is:

(1) Horizontal transport machinery: idle fuel consumption × Queue waiting time

(2) Loading and unloading machinery: bridge idle rate × Operating time ×static state power consumption

According to the carbon emission policy, the terminal operator has a fixed carbon quota allocated by the government according to the rules. When the car-bon emissions exceed this quota, the terminal needs to pay extra carbon emission costs. The more carbon emissions, the equivalent of indirectly increasing the operating costs of the terminal. The carbon emission calculated in this paper is the carbon emission of CO_2 , and the calculation method is the emission factor method proposed by IPCC [16]. Among them, the carbon emission of the truck comes from diesel, and the shore power comes from coal in fossil energy.

3. Establishment of the Model

The purpose of overbooking is to intentionally release more appointment shares on the platform that exceed the actual service capacity of the terminal, so that the actual arrival of the truck is infinitely close to the appointment arrival, so how to determine the number of overbooking of the container truck is the key to achieve the goal and solve the problem. The more the appointment quota of the collection truck is over-booked, the less the possibility of the no-show of the truck, but the greater the possibility of being denied service by the system, which will increase compensation of the system denied service. The smaller the number of overbooking is, the less likely it is to be denied service by the system, but the more likely it is that the truck will be absent, and the idling loss of system equipment will increase accordingly. Therefore, the following two situations to sum up:

(1) Excessive overbooking, after the system in-creases the appointment quota of overbooking, the amount of actual arrived collection trucks exceeds the service capacity of the system, and the exceeded part of container trucks cannot be served in time. Therefore, terminal operators need to compensate for them, resulting in compensation for overbooking costs.

(2) Insufficient overbooking, after the system in-creases the appointment quota of overbooking, the actual arrived container trucks do not fully fill the system capacity, and some facilities and equipment at the dock are idling, which will result in the cost of equipment idling.

Use American English when writing your paper. The serial comma should be used ("a, b, and c" not "a, b and c"). In

American English, periods and commas are within quotation marks, like “this period.” Other punctuation is “outside”! The use of technical jargon, slang, and vague or informal English should be avoided. Generic technical terms should instead be used.

3.1. Model Assumption

(1) The order of receiving service of the container card is first come first service;

(2). Model does not consider the breakdown of terminal facilities and equipment;

(3). There is no heterogeneity in the service time of the truck at the gate and the yard, that is, the service capabilities are the same;

(4). No-show of the container truck is independent of each other;

(5). No-show is random and subject to binomial distribution;

(6). In each appointment time window, the yard bridge and the quayside bridge respectively serve the external and internal container trucks, and the model does not consider the situation of serving the internal collection cards at the same time;

(7). Model considers the capacity limit of the yard. When the number of trucks queuing in the wait-ing area of the yard reaches the capacity limit, the gate will not let the following trucks in.

3.2. Model Symbols

p : Appointment period in the decision period, $p=1,\cdots P$

t : The time interval subdivided within the appointment period, $t=1,\cdots T$

i : Container terminal gate channels, $i=1,\cdots I$

j : Number of container terminal yard, $j=1,\cdots J$

N : Decision-making cycle of port gathering

μ_{it}^{g} : Service capacity of gate channel i in the time interval t

μ_{jt}^{y} : The service capacity of the yard bridge j built in the time interval t

γ : Capacity limit of the yard buffer area

e : Fuel consumption for one hour at idle speed

V : Diesel engine displacement

n : Engine speed per minute

P^{j} : Power of shore power consumed when the yard bridge is in dynamic state

P^{y} : Power of shore power consumed when the yard bridge is in static state

θ_o : Carbon emission factor of diesel

θ_e : Carbon emission factor of electricity

f_o : Carbon emission trading price of diesel

f_e : Carbon emission trading price of electricity

r : Probability of occurrence of each truck

λ_{it}^{g} : The arrival quantity of trucks at the gate channel i in the time interval t

λ_{jt}^{y} : The arrival quantity of trucks in the yard j in the time interval t

ρ_{it}^{g} : Utilization rate of gate channel i in the time interval t

ρ_{jt}^{y} : Utilization rate of the yard j in the time interval t

l_{it}^{g} : The queue length of trucks at the gate channel i in the time interval t

l_{jt}^{y} : The queue length of trucks in the yard j in the time interval t

d_{it}^{g} : The departure number of trucks at the gate channel i in the time interval t

d_{jt}^{y} : The departure number of trucks in the yard j in the time interval t

δ^2 : Service time variance of the yard bridge

w^{g} : Average waiting time of trucks at the gate channel in the time interval t

w^{y} : Average waiting time of trucks in the yard in the time interval t

L : The loss cost of system equipment idling

C : The compensation paid by the terminal for the truck when the system refuses to service a truck, a constant

k : Number of absent cards during the period p

E : Expected cost of overbooking

$\overline{\lambda_p^{g}}$: The actual arrival quantity of trucks in the period p

λ_p^{g} : In the period of time p, the system released the overbooking shares of container cards, decision variables

3.3. Specification of the Model

$$MinZ = E+\left(w^{g}+w^{y}\right)\cdot e\cdot\theta_o\cdot f_o + \sum_{j=1}^{J}\sum_{t=1}^{T}\left(1-\rho_{jt}^{y}\right)\cdot P^{y}\cdot\frac{24N}{T}\cdot\theta_e\cdot f_e \tag{1}$$

Formula (1) represents the cost of unnecessary carbon emissions generated in the process of port collection by the container card.

$$e = 0.79\cdot V\cdot n\left(ml/h\right) \tag{2}$$

Formula (2) shows the calculation method of fuel consumption of the container truck's engine idling for one hour.

1. Constraints of arrival mode

$$\overline{\lambda_p^{g}} = \lambda\cdot r \tag{3}$$

$$k = \lambda - \overline{\lambda_p^{g}} \tag{4}$$

$$\lambda_p^{g} \geq 0 \ \ \forall p \tag{5}$$

Equation (3) represents the actual arrival of the truck after overbooking; Equation (4) represents the number of absent cards in the period; Formula (5) indicates that the arrival volume of the truck should be a non-negative integer;

2. Overbooking cost

$$E=\sum_{k=0}^{\lambda} r_k \cdot E=\sum_{k=\lambda-\overline{\lambda_p^g}}^{\lambda} r_k \cdot E\left(\max\left(0,\lambda_p^g-\overline{\lambda_p^g}\right)\right)\cdot L + \sum_{k=0}^{\lambda-\overline{\lambda_p^g}} r_k \cdot E\left(\max\left(\overline{\lambda_p^g}-\lambda_p^g,0\right)\right)\cdot C \quad (6)$$

Equation (6) indicates that the expected cost of overbooking is composed of the waste caused by resource depletion when overbooking is insufficient and the overbooking compensation paid by the terminal to the hub when overbooking is excessive. The expected cost expression of overbooking should be the expected cost of probability, which is the sum of the product of the cost and the corresponding probability of occurrence of all possible missed trucks in both cases.

$$r_k\left(X=k\right)=C_\lambda^k \cdot r^{\lambda-k}\left(1-r\right)^k \quad (7)$$

Equation (7) indicates the rate that there are just absent trucks of k; the binomial distribution （λ ，r） is derived from the fact that the share of overbooking reservation released by the terminal is λ_p^g, while the number of actual arriving is $\overline{\lambda_p^g}$, and absent trucks is k.

$$L=P^j \cdot \mu_{jt}^y \cdot \theta_e \cdot f_e-\frac{\left(w^g+w^y\right)}{\overline{\lambda_p^g}} \cdot e \cdot \theta_o \cdot f_o \quad (8)$$

Equation (8) represents the loss of the system caused by the absence of the collection card; When the actual arrival quantity of the truck is less than the reservation quantity released by the terminal, the system has one less truck to accept the service, which is equivalent to reducing the carbon emissions generated by one truck, but increasing the idling rate of the field bridge.

3. Gate queuing: M/M/1:

$$\lambda_t^g=\frac{\lambda_p^g}{m} \quad (9)$$

$$\lambda_{it}^g=\sum_{i=1}^{I}\lambda_t^g / I \quad (10)$$

$$l_{i(t+1)}^g=\max(l_{it}^g+\lambda_{it}^g-d_{it}^g,0) \quad \forall i\in I,t\in T \quad (11)$$

$$d_{it}^g=\mu_{it}^g \cdot \rho_{it}^g \quad \forall i\in I,t\in T \quad (12)$$

$$l_{it}^g=\frac{\rho_{it}^g}{1-\rho_{it}^g} \quad \forall i\in I,t\in T \quad (13)$$

$$w^g=\sum_{t=(p-1)m+1}^{pm}\sum_{i=1}^{I} l_{it}^g / \sum_{(p-1)m+1}^{pm}\sum_{i=1}^{I} d_{it}^g \quad \forall i\in I,\forall t\in T \quad (14)$$

Equation (9) means that the PSFFA algorithm is used to convert the arrival volume of the truck in the whole reservation period into the arrival volume of each time interval; Equation (10) indicates that the arrival quantity of the truck is evenly distributed to the gate channels; Equation (11) indicates that the flow conservation relationship in the PSFFA algorithm is followed: the change of the gate queue length in the time interval=the arrival quantity of the hub - the departure quantity of the hub; Formula (12) indicates that the departure volume of the truck at the gate is equal to the service volume of the truck in the yard; Equation (13) shows the relationship between gate queue length and gate channel utilization; Equation (14) represents the average waiting time of the truck at the gate during the reservation period.

4. Yard queueing （M/G/1）:

$$\lambda_t^y=\sum_{i=1}^{I} d_{it}^g \quad (15)$$

$$\lambda_{jt}^y=\sum_{j=1}^{J}\lambda_t^y / J \quad (16)$$

$$l_{j(t+1)}^y=\max(l_{jt}^y+\lambda_{jt}^y-d_{jt}^y,0) \quad \forall j\in J,t\in T \quad (17)$$

$$d_{jt}^y=\mu_{jt}^y \cdot \rho_{jt}^y \quad \forall j\in J,t\in T \quad (18)$$

$$l_j^y=\rho_{jt}^y+\frac{\left(\rho_{jt}^y\right)^2+\left(\lambda_{jt}^y \cdot \delta\right)^2}{2\left(1-\rho_{jt}^y\right)} \quad (19)$$

$$l_j^y \le \gamma \quad (20)$$

$$w^y=\sum_{t=1}^{T}\sum_{j=1}^{J} l_{jt}^y / \sum_{t=1}^{T}\sum_{j=1}^{J} d_{jt}^y \quad \forall j\in J,\forall t\in T \quad (21)$$

Formula (15) indicates that the number of trucks arriving at the storage yard within the time interval is equal to the sum of the departure quantities from the gate; Formula (16) represents the number of containers arriving at each yard partition within the time interval; Equation (17) represents the flow conservation relationship in the PSFFA algorithm. The change of the queue length of the truck in the yard partition is equal to the arrival quantity of the truck minus the departure quantity; Formula (18) indicates the number of trucks leaving the queuing system after the service in the container area is completed within the time interval; Equation (19) shows the relationship between the queue length of the truck at the yard partition and the utilization rate of the yard bridge; Formula (20) indicates that the number of trucks queuing in the waiting area of the yard does not exceed the maximum capacity of the waiting area of the yard; (21) Indicates the average waiting time of the truck in the storage yard during the reservation period.

4. Example Analysis

4.1. Algorithm Design

In this paper, based on queuing theory, the optimization model for overbooking of container trucks is a nonlinear and NP-hard optimization problem, so genetic algorithm is used to solve the model. However, the traditional genetic algorithm is easy to fall into the part optimal solution in the iterative process, and the high-quality solution is also easy to be lost in the calculation process, resulting in degradation. If the parameters are not good enough at the beginning of set, the solution quality will be affected. Therefore, this paper designs an adaptive genetic algorithm based on many experiments, and changes the crossover rate and mutation rate according to the iterative process of the algorithm, so that the algorithm has autonomy, which not can also be said to be adaptive. It not only retains the original advantages of genetic algorithm, but also improves the search accuracy of the algorithm and saves the operation time. Figure 3 shows the flow of adaptive genetic algorithm:

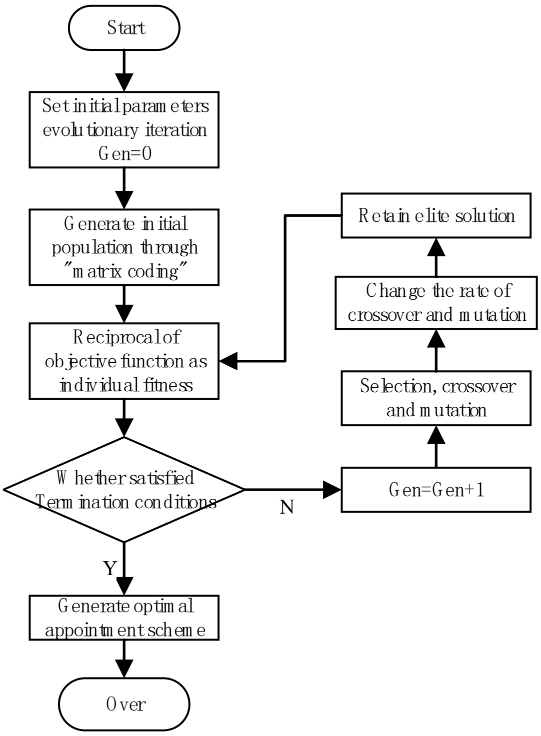

Figure 4. Flow chart of AGA

Step 1: The initial population's generation: during the decision-making period, the reservation share provided by the terminal to the collection card corresponds to a chromosome, and the length of the chromosome is the number of reservation time windows in the decision-making week. The real number coding method is adopted, and the initial population size is set to 100;

Step 2: fitness evaluation: This paper studies the problem of cost minimization, so the reciprocal of the objective function can be used as the fitness value;

Step 3: Selection and crossover operation: the elite strategy is introduced to retain the individuals with the highest fitness value obtained from the previous generation in the new generation of population, and the remaining individuals use the roulette selection method to randomly select two operators from the parent generation for two-point crossover to generate a new offspring. The crossover probability is adjusted according to the fitness value of each generation of individuals. The adjustment process is shown in formula (21), which will be regarded as the maximum crossover probability, As the minimum crossover probability, it is the larger fitness value of the two individuals performing crossover operation, the largest fitness value in the group, and the average fitness value of the group.

$$pc = \begin{cases} pc_1 - \dfrac{(pc_1 - pc_2)(f' - f_{avg})}{(f_{\max} - f_{avg})}, & f' > f_{avg} \\ pc_1, & f' \le f_{avg} \end{cases} \tag{1}$$

Step 4: Variation operation: randomly select a point on the chromosome to change the variation variable to a random integer between [- 5,5]. If the sum of all gene values on the chromosome after variation minus the value before variation is positive, then find the maximum gene value on the chromosome after variation minus the difference; If it is negative, then find the smallest gene value on the chromosome after mutation minus the difference. The constraint condition is that all gene values on the chromosome are non-negative integers. The mutation probability is adjusted independently according to the number of iterations; The adjustment process is shown in formula (22): the mutation probability is automatically adjusted according to the evolution algebra. It will be regarded as the maximum mutation probability, the minimum mutation probability, the current evolution algebra, and the maximum evolution algebra.

$$pm = pm_1 - \frac{(pm_1 - pm_2) \cdot gen}{gen\_\max} \tag{2}$$

Step 5: Termination condition: When the iteration process reaches the maximum evolution number set by the algorithm, the algorithm terminates, and the individual with the maximum fitness value is taken as the optimal solution of the model.

4.2. Example Solution

Taking the data of a certain period of time at Chongqing Guoyuan Port Terminal as an example, the model scenario includes 7 gate channels and 15 field bridges serving the external truck. The operation time of the terminal is 24 hours, the average time window of each reservation is 2 hours, and the decision-making time is one week. There are 84 time windows in total. In order to test the effectiveness of the model and algorithm, this paper uses Matlab2016a software for simulation: running on an Intel i5 processor with a main frequency of 2.42 GHz and a memory of 16.00GB.

4.3. Result Analysis

The convergence process is shown in Figure 3: after 400 generations, the convergence curve gradually tends to be stable; Compared with the ordinary reservation, the non-essential carbon emission cost in the process of collecting cards before the reservation is 78126 yuan, and the non-essential carbon emission cost for the optimization of the over-booking reservation is 33890 yuan, while the non-essential carbon emission cost for the ordinary reservation is 27995 yuan when taking into account the random default.

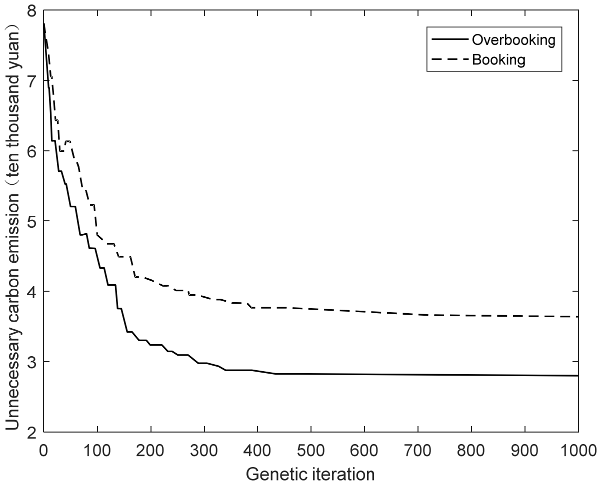

Figure 4. Convergence process of AGA

Secondly, by comparing the arrival rules of the outbound truck before and after the overbooking, the variance of the outbound truck arrival before the booking is 475.36, after the booking, the variance de-creases to 136.93, and after the overbooking, the variance decreases again to 126.55; According to Figure 5, the reservation can indeed alleviate the irregularity of the arrival of the truck to some extent. The centralized arrival of the truck in the peak period is scattered in other idle time periods, and the average arrival of the truck is stable at about 30 vehicles per time period; However, by using overbooking to optimize the reservation share, the probability of the occurrence of the collection card has increased, and the arrival volume of the collection card has increased, with an increase of about 60 vehicles per decision period. The increased number of trucks may also bring more benefits to the terminal.

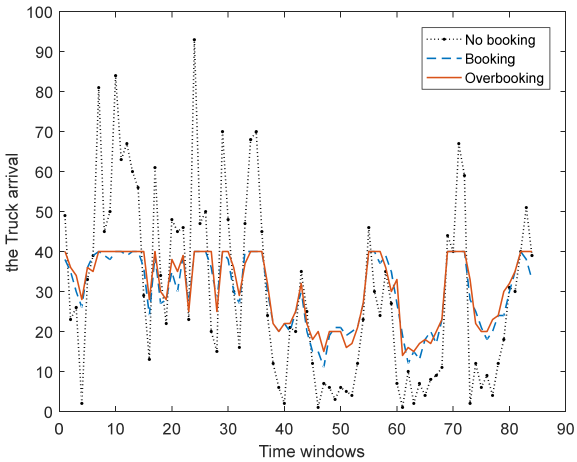

Figure 5. Truck waiting time before and after booking at gate

The regular change of the queue length at the gate and the yard is shown in Figure 6. The queue length at the gate decreases from 3.46 minutes before the reservation to 2.93 minutes after the ordinary reservation, and increases to 3.03 minutes after the overbooking; the queue length in the storage yard decreased from 13.1 minutes before the reservation to 7.31 minutes after the ordinary reservation, and increased to 7.53 minutes after the overbooking. The average waiting time of the whole process decreased from 16.6 minutes before the appointment to 10.2 minutes after the appointment and then to 10.7 minutes after the overbooking; the maxi-mum waiting time of the truck at the dock was reduced from 43 minutes to 19 minutes. It shows that booking can indeed improve the efficiency of the collection of the container trucks. By using the overbooking to optimize the reservation share, the missed appointment of the container trucks has been alleviated, and the number of arrival of the container trucks by appointment has increased, thus extending the queuing time, which is within a reasonable range of changes.

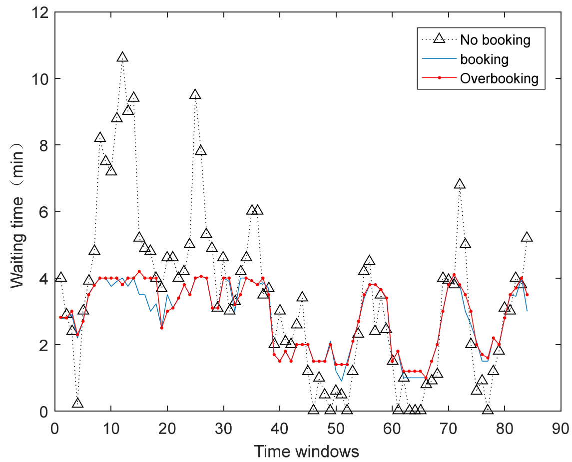

Figure 6. Truck waiting time before and after booking at yard

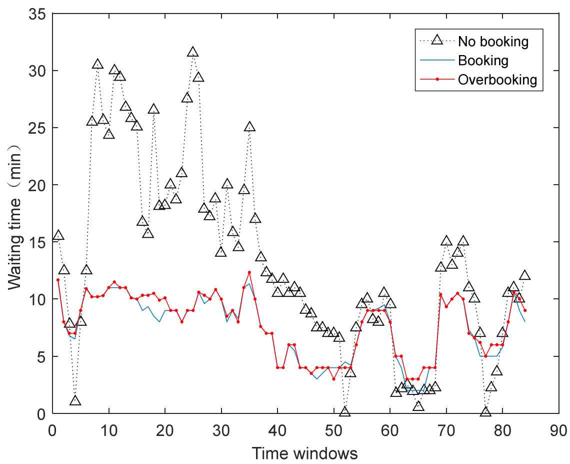

Figure 7. the Law of truck arriving before and after booking

Finally, the research in this paper is based on the common reservation. The comparison results of the data in Table 2 can reflect the efficiency of port collection in various situations in a decision-making period from the perspective of carbon emissions.

Table 1. Comparison of results before and after optimization

Parameters	No Booking	Booking	Overbooking
utilization rate of yard bridge	67%	81%	92%
Carbon Emission of CO_2	5	213	644
Average queueing time	213	654	649

To sum up, the study of the default behavior of the container truck can obtain the impact of the arrival probability of the container truck on the carbon emissions of the port terminal, so as to ensure the lowest carbon emissions in the process when formulating the overbooked reservation plan. At the same time, it can more effectively restrict the irregularity of the arrival of the container trucks, reduce the waiting time of the container trucks at the terminal, and improve the utilization rate of the port facilities and equipment.

5. Conclusion

Irregular arrival of container trucks has always been the key factor that causes congestion at the gate and yard of the terminal and low efficiency of port collection. The terminal can make arrangements for the port collection process in advance through the container booking system, so that the terminal resources can be reasonably allocated. However, even if there is an appointment system, the arrival of the collection card still has the situation of random missed appointments. Especially under the influence of the epidemic in the past two years, the arrival of the truck is more unstable, and the appointment plan is at risk of being forced to cancel at any time, so the problem of missed appointment needs to be considered in the appointment. In addition, the goals of "carbon peak", "carbon neutral" and "world-class port" put forward higher requirements for the port to fulfill its social responsibility and high-quality development. Therefore, this paper also considers carbon emissions in the optimization. In terms of carbon emissions, it also considers the power air consumption when the truck is idling and the bridge is in static condition, and calculates the carbon emission cost that can be saved more accurately.

On the basis of the existing research on the optimization of container booking, this paper takes into account the phenomenon of missed appointments in the process of container collection, uses the idea of airline ticket overbooking to alleviate the problem of missed appointments, takes the minimum unnecessary carbon emissions lost in the process of container col-lection as the goal, uses the adaptive genetic algorithm to solve the problem, and takes Chongqing Guoyuan Port as an example to verify and analyze the model and algorithm. The results show that the terminal intention-ally releases more reserved shares to the outside world, It is not only optimized from the perspective of both the truck and the terminal, but also from the perspective of the overall environment. While reducing the queuing time of the truck and reducing the carbon emissions of the terminal, it also improves the resource utilization rate, which is more scientific and efficient than the conventional reservation strategy in the past. However, this paper only focuses on the absence of the pickup truck. In the follow-up study, the early arrival and late arrival of the pickup truck can be considered together. While doing a good job in advance prevention, on-site scheduling is also arranged to make the pickup truck reservation system more comprehensive and complete.

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