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Research on airport trailer emergency scheduling model based on genetic simulation annealing algorithm

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Abstract. With the increase of air transport business year by year, the airport comprehensive service capabilities are increasingly facing severe challenges. As a key part of airport service, ground scheduling is crucial to the departure of flights on time. by analyzing the traditional rules of airport trailer and combining with the service processes and the characteristics of trailers, the paper develops a multi-target trailer emergency scheduling model with rolling windows. When the model is solved, the simulation annealing algorithm is introduced into the genetic algorithm to prevent the optimal result falling into the local optimal solution. The simulation results show that the model can more effectively solves the problem of airport trailer emergency scheduling in the case of flight delays than the traditional scheme,and to relieve the pressure of flight delay for busy airports.

1. Introduction

With the increase of air transport business year by year, the airport comprehensive service capabilities are increasingly facing severe challenges. As a key part of airport service, ground scheduling is crucial to the departure of flights on time.

At present, most of the airport flight scheduling service is still in the manual scheduling phase[1], adopting the First in first out scheduling strategy.Although the operation is simple,efficiency is low. It is obvious no value for solving the flight delay when the weather suddenly changes,flight delays, Special vehicle breakdown and other emergencies,Especially.the ground scheduling of trailers during the flight access to station operation is studied by Jiayan Du [2-3],developing a VRPTW model according to the operation flow of the towing vehicle and Minimizing the total scheduling time cost of the entire process .simultaneously,Xia Feng[4]has established the coordinated scheduling model of refuel tanker and shuttle bus with taking the refueling service and pick-up service time of flights as the constraint,and aimed at the objective of minimizing the number of safeguards and making the total starting time of service earliest, and given model solution based on multi-objective genetic algorithm.

The paper develops a trailer emergency scheduling model, by analyzing the traditional rules of the trailer scheduling based on the existent researches and related papers,and combining with the service flow and time characteristics of the trailer,then gives the optimized scheduling scheme.

2. Traditional trailer scheduling strategy

Now, most airports adopt the First in first out strategy in the airport trailer scheduling [5].The strategy,which is to select a grouping scheme from the scheduling system,and the grouping which can be completed in the shortest time t_i in the GPS system corresponding to the scheduling system is selected for transmission. Among all the grouping schemes waiting to be scheduled (see figure 1).It is confirmed that the time which takes for the packet completion service lags behind the time it takes to transmit the longest packet on the process ,comparing with the corresponding GPS system [6].

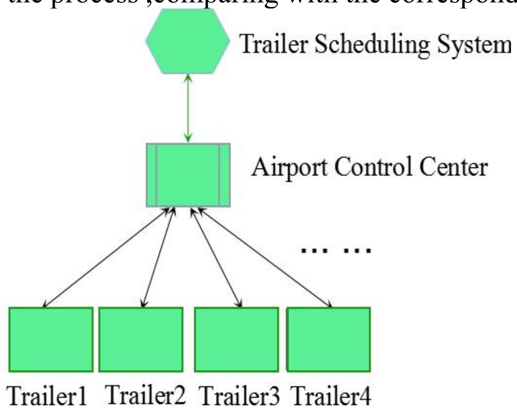

Figure 1. The structure of traditional trailer scheduling.

When a trailer group arrives,it will be sorted into the corresponding queue by classification.the scheduling system will calculate the completion time of the process,at the same time [7].Then select the packet with the shortest completion time among the packets as the next packet transmitted from the output port, and the packet period is T.

Among them, the scheduling time is calculated as follows: $v(0)=0$, and

$$v(t_{j-1}+T)=v(t_{j-1})=T/\sum_{i\in B}\phi_i, T\le t_j-t_{j-1}, j=2,3,\cdots \tag{1}$$

In the above equation(1),the scheduling of the trailer as one event, and t_j represents the time of the j th event finished .

The complexity of the scheduling system is expressed as $\mathrm{O(M)}$, and M is the number of connected trailers.In the scheduling process, the (σ_i, r_i) is used as the constraint of scheduling algorithm, and the node trailer scheduling delay as follows equation(2) [8]:

$$f(\sigma_i, r_i)=\frac{\sigma_i}{r_i}+\frac{L_{\max}}{C} \tag{2}$$

Among them, C is the service rate of the server,and $\mathrm{L_{max}}$ is the maximum of the packet length of vehicles.

3. Trailer emergency scheduling model

The paper develops a trailer emergency scheduling model,and gives the optimized scheduling scheme.

3.1. putting forward of the problem

According to the conventional ground specific vehicle scheduling strategy, the nearest trailer is assigned at the current time, but the actual distance between the current failed trailer and the next trailer in the group is ignored. And the trailer's work flow is chained with strict scheduling rules and time constraints. A change of a link or a group of trailers may cause subsequent trailers to fail to schedule normally and affect the normal launch of subsequent flights. In order to efficiently schedule flights under the condition, it is necessary to optimize the scheduling strategy and improve the level of ground scheduling and security.

So, the paper develops a multi-target trailer emergency scheduling model with rolling windows.and gives a certain number of delayed flights and serviceable trailers, we construct a coordinated emergency scheduling model for all kinds of trailers with flight delays and assign them to service needed flights according to the traction of trailers, and gives the start time of services in the process of scheduling.

3.2. Model building

3.2.1. Model description and symbolic description

In this paper, the rolling window strategy is used to divide the flight delay time into multiple equal time periods. After that, the flights in each time period are optimized according to their planned take time-off time and delay time.In this way, not only can the scheduling plans of delayed flights be developed quickly, but also the real-time processing of flight information can be ensured.

In the actual operation of the airport scheduling, the trailers are divided into three categories called small, medium and large.The specific information as the table1 show.

Table 1. the correspondence between flight models and the type of trailers.

Aircraft type	Representative	Carrying capacity	trailer type
Large airliner	B747/A340/A380	Over 200 people	Large
Medium airliner	B737/C919/A320	Between 100and200	Large/Medium
Small airliner	ARJ21/MA60	less than 100 people	All

Suppose the step size of the rolling window is L, the starting time value is Q, the rolling window is RW_t at time t is taken as[Q+(t-1)*L,Q+t*L].According to graph theory, the multi-target trailer emergency scheduling model can be abstractly represented as a graph G=(FG,EG,SE,NG),when the flight is delayed.Where FG represents the number of delayed flights N in the rolling window RW_t; EG represents the path from the trailer to the delayed flight position in the rolling window RW_t (N scheduling paths are generated for N delayed flights); SE represents the window on which the towing flight is trailed in the rolling window RW_t ; NG indicates the number of the trailer in the rolling window RW_t(the total numbers of the trailers is p).For each late flight $i \in$ FG, there is a latest departure time O_i (the flight will be excluded in the current window RW_t beyond which the latest departure time) and the time window $SE_i = [s_i, e_i]$ $(e_i < O_i)$ [8].

For each scheduling path k, s_{kj} represents the time when the trailer j starts to schedule a delayed flight in the flight schedule path k, that is the trailer j arrives at the scheduled downtime. If there is a trailer j in the scheduling path k, then $x_{kj} = 1$, otherwise $x_{kj} = 0$.

3.2.2. Model assumptions

In the following study in this paper, for the delay of departure flights, the establishment is based on the following assumptions:

- Each flight happens to be towed once.
- The flight has been completed refueling, boarding and other work, the trailer towed to the taxiway can be released takeoff.
- During the process of receiving the towing service, the towing vehicle will not malfunction and other events that affect scheduling will occur.
- Once the trailer has started its work, it will not be interrupted until the end of the service.

3.2.3. trailer emergency scheduling model constraints

Trailer emergency scheduling model constraints is extremely limited and in order to operate safely, all kinds of special vehicles must travel at a fixed path and speed.in the flight scheduling process, the use of the trailer must be in accordance with the "flight-trailer" corresponding mode to draw the flight.

Second, the number of trailers, the departure time of the flight, the constraints in the rolling window [Q + (t-1) * L, Q + t * L] are now defined as follows.

Due to delayed flight and scheduling path one by one, so there $x_{kj} = x_{ij}$. For subsequent convenience and verification, the following x_{kj} is indicated by x_{ij} . The number of trailers and delayed flights as follows equations(3)-(4) :

$$\sum_{a=1}^{3} p_a = P \quad , \sum_{b=1}^{3} n_b = N \quad , i = 1,2,3 \cdots N \text{ , j=1,2,3} \cdots P . \tag{3}$$

$$\sum_{i=1}^{N} \sum_{j=1}^{P} x_{ij} \le P \tag{4}$$

Time constraints in the scheduling process are as follows equations (5)-(7):

$$\sum_{i=1}^{N} x_{ij} \le O_i, \quad \forall i \in FG \tag{5}$$

$$e_{i-1} + T_{i+1} < s_i < e_i \tag{6}$$

$$Q + (t-1) * L < s_i < e_i < Q + t * L, i \in EG \tag{7}$$

3.2.4. Trailer emergency scheduling optimization goals

According to the actual operation of the airport and the emergency scheduling model of the above trailer, the various types of trailers under the condition of flight delay are optimized to achieve the goal of minimizing the total service time of all delayed flights,as follows equation (8).

$$T_{\min} = \sum_{i=1}^{N} \sum_{j=1}^{P} x_{ij} \cdot T_{ij} \tag{8}$$

3.3. Model solution

According to the above model, the key to solve the delay flight scheduling path problem is to reasonably determine the relationship between the flight and each trailer, to minimize the total delay time when the corresponding types of flights and trailers and the departure time of flight are satisfied, and to avoid genetic algorithm (GA) is easy to fall into the condition of local optimization and slow convergence of simulation annealing algorithm (SAA), and a model based on simulation annealing genetic algorithm to solve the emergency scheduling of trailers is constructed [9-11].

3.3.1. Algorithm steps

The specific idea of simulation annealing genetic algorithm is as follows:

Step 1: Initializing the control parameters. The population size is N , the mutation probability is P_m , the initial annealing temperature is T_0 , the temperature cooling parameter is α .

Step 2: Construct chromosomes $C_h(h = 1,2,\cdots N)$ to generate initial population.For example, chromosomes {6, 2, 5, 4, 1, 3} indicate that flight number 1 is the 6th towing service, flight number 2 is the second towing service, and so on.

Step 3: Calculate fitness.For each chromosome C_h generated in the population, to determine whether the corresponding feasible solution after decoding.If the corresponding solution is feasible, the corresponding objective function value Z_h is obtained.If the chromosome C_h corresponds to a non-feasible solution, a large integer M is assigned.The fitness function $f_h = 1/\mathrm{Z_h}$, f_h is the greater the value, indicating that the algorithm is close to the optimal solution.

Step 4: Chromosome cross.Select two individuals C_i and C_j randomly and perform partial matching crossover(PMX)to generate two new individuals C_i' and C_j' , and then calculate their fitness

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function values f_1' and f_2' . If $\min\{1, \exp(-(f_h - f_h')/T_k)\} > b$, b is a random number between 0 and 1, then the current individual is received;

Step 5: The cross after the above-mentioned individual mutation operation, combined with the fourth step of the method to determine whether to receive the variant solution.

Step 6: to determine whether to meet the convergence conditions. Otherwise, $T_{k+1} = \alpha * T_k$,turn to the step 3,and continue to find the optimal solution.

4. Application examples

Based on the above trailer emergency scheduling model, this section will use the delayed flight data as an example that to verify the reliability of the scheming model,and comparing with the conventional trailer scheduling method. The scheduling time for each flight is assumed to be 10 minutes.Specific flight information as follows table 2.

Table 2. Delay flight information at 19:20 on day.

Flight number	Flight type	Original schedule time	Current Flight schedule	Current Trailer state	Flight number	Flight type	Original schedule	Current Flight schedule	Current Trailer state
CA1302	large	17:30	20:30	large1	CZ2203	large	19:50	20:40	
CZ2201	Medium	17:40	19:25	Medium3	CA1322	Small	20:05	20:45	
CF3105	Medium	17:55	19:30	Medium4	MF1268	Medium	20:20	20:50	
HU6681	Small	18:10	19:40	Small6	CF3109	Medium	20:25	21:00	
CA1308	Small	18:25	19:45	Small7	CA1338	Medium	20:32	21:10	
MF1241	Small	18:40	19:50	Small8	CZ2204	Small	20:45	21:15	
CZ2202	Small	18:55	19:55	Medium5	CA2356	Small	21:10	21:20	
CA1307	Medium	19:15	20:10	large2	CF3111	large	21:30	21:30	
CF3106	large	19:20	20:15		HU6688	Medium	21:35	21:35	
HU6682	Small	19:30	20:35		CZ2205	large	21:40	21:40	

According to the traditional "First in first out" strategy, the trailer number 1-8 is a scheduling group.The actual scheduling time as show in the table 3.

Table 3. The traditional scheduling strategy actual scheduling situation.

Flight number	Schedule trailer	The actual scheduling time			Flight number	Schedule trailer	The actual scheduling time		
		First group	Second Group	Third group			First group	Second Group	Third group
CA1302	large1	20:30			CZ2203	large1		20:50	
CZ2201	Medium3	19:25			CA1322	Small7		20:55	
CF3105	Medium4	19:30			MF1268	Medium3		21:00	
HU6681	Small6	19:40			CF3109	Medium4		21:05	
CA1308	Small7	19:45			CA1338	Medium5		21:10	
MF1241	Small8	19:50			CZ2204	Small8		21:15	
CZ2202	Medium5	19:55			CA2356	Small6			21:25
CA1307	large2	20:10			CF3111	large2			21:30
CF3106	large2		20:40		HU6688	Medium3			21:35
HU6682	Small6		20:45		CZ2205	large1			21:40

According to the table 2 and table 3,we can know that total actual delay time of the flight :75min.

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However,according to the proposed cooperative scheduling of various types of trailers based on genetic simulated annealing algorithm for scheduling flights, set L = 30min, N = 20, the mutation probability $P_m = 0.005$, initial temperature $T_0 = 100^{\circ}C$, the actual scheduling situation is as follows figure 2 and table 4.

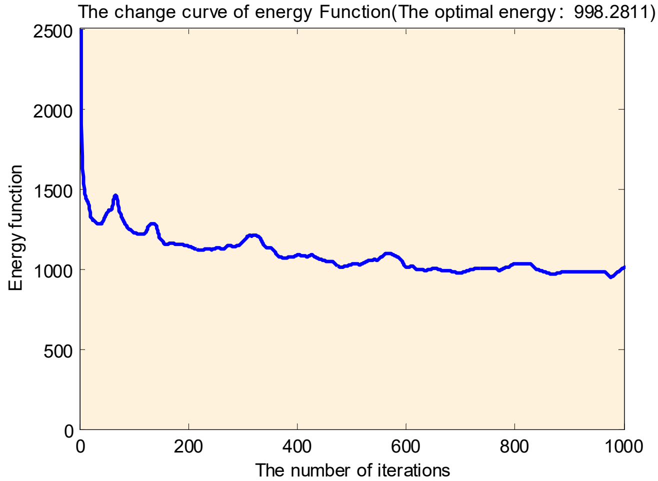

Figure 2. The change curve of energy Function.

Table 4. The trailer coordinated emergency scheduling plan actual scheduling situation.

Flight number	Schedule trailer	Scheduling time Window				Flight number	Schedule trailer	Scheduling time Window			
		1	2	3	4&5			1&2	3	4	5
CA1302	large2			20:30		CZ2203	large1		20:40		
CZ2201	Medium3	19:25				CA1322	Small8		20:45		
CF3105	Medium4	19:30				MF1268	Medium4		20:50		
HU6681	Small6	19:40				CF3109	Medium5			21:00	
CA1308	Small7	19:45				CA1338	Medium3			21:10	
MF1241	Small8	19:50	20:00			CZ2204	Small6			21:15	
CZ2202	Small6		20:05			CA2356	Small7			21:20	
CA1307	Medium3		20:10			CF3111	large1				21:30
CF3106	large1					HU6688	Medium4				21:35
HU6682	Small7			20:35		CZ2205	large2				21:40

According to the table 2 and table 4,can see that the above trailer emergency scheduling method which is only a total delay of 15 minutes on the basis of the current flight schedule.

5. summary

By analyzing the traditional rules of airport trailer and combining with the service processes and the characteristics of trailers,the paper develops a multi-target trailer emergency scheduling model with rolling windows.And the simulated annealing algorithm is introduced into the genetic algorithm to prevent the optimal result falling into the local optimal solution when the model is solved. The simulation results show that the model can more effectively solve the problem of airport trailer emergency scheduling in the case of flight delays.In the future research work,we can refine the relevant factors and go further quantitative analysis to improve the efficiency of airport scheduling.

References

[1] Makhloof M A,Waheed M E and Badawi U A E R 2014 Real-time aircraft turnaround

operations manager *Production Planning&Control* 25 (1) pp 2-25
[2] Du J Y,Jens B 2014 Planning towing processes at airports more efficiently Transportation Research *Logistics and Transportation Review* 70 (1) pp 293-304
[3] Angus C; Ip W H,Lu D 2005 An aircraft service scheduling model using genetic algorithms *Journal of Manufacturing Technology Managemen*t 16 (1) pp 109–19
[4] Feng X, Ren Z Y 2016 Research on collaborative scheduling of refueling trucks and ferry pushes based on genetic algorithm *Journal of Transportation Systems Engineering and Information Technology* 16 (2) pp 155-63
[5] Sun D W, Chang GR; Wang C,Xiong Y,Wang XW 2010 Efficient Nash equilibrium based cloud resource allocation by using a continuous double auction *International Conference on Computer Design and Applications* pp 194-99
[6] Jing H M ,Zhang L J 2007 Modeling and simulation of vehicle scheduling problem with multiple vehicles *Computer simulation* 17(8) pp 261-64
[7] Lu J W 2010 Preferred method of test nodes based on genetic particle swarm compound arithmetic *Computer Measurement & Control* 54 (2) pp 1036-38
[8] Wang J H,Shi M Y,Wang T T 2012 Coverage optimization of mobile nodes based on QPSO *Microelectronics & Computer* 33 (2) pp 96-99
[9] Zhang Y X,Qi Y X 2017 Improved genetic simulated annealing algorithm for solving TSP *Intelligent Computer and Application* 7(3) pp 52-54
[10] He Q,Wu Y L 2017Application of Improved Genetic Simulated Annealing Algorithm in TSP Optimization *Control and decision making* 13 (10) pp 1-7
[11] Lin Z L 2009 Coverage optimization strategy of wireless sensor networks based on particle swarm optimization *Computer simulation* 26 (4) pp 190-93