The Auto Evaluation Method of Airline

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Abstract. In order to evaluate the effectiveness of automatically generated attack airline from mission planning system. The evaluation model is put forward, which is the integration of fuzzy theory, the grey system theory and multi-objective decision method of TOPSIS (Technique for Order Preference by Similarity to an Ideal Solution) method. First the fuzzy theory is adopted to process the weights of airline evaluation index, using grey system theory to calculate the TOPSIS distance between airline evaluation values to the positive and negative ideal solution; At last calculating the grey correlation relative closeness. Through the case analysis, the feasibility and effectiveness of the method is illustrated.

Introduction

Air strikes have the characteristics of sudden strong, accurate strike, long distance and so on. It is a common method of modern war. But as the development of the air defense system, the radar and the air defense missile are the great threat to the aircraft. In order to respond to the threat of air defense, the aircraft in the technology has also been developed, such as stealth, speed, intelligent planning and other techniques. The COA(course of action) produced by mission planning system is becoming more and more accurate, close to the actual scene. The attack airline in COA, which is based on the simulation of radar detecting and the shooting of air defense missile, is generated according to real 3D terrain. In recent years, there are a lot of methods for automatic generation of 3D flight routes, such as in literature[1-3] . Now the problem is how to evaluate airlines based on operational requirements of commander.

General civil airline evaluation refers to airline safety, comfort, economy and so on, to provide technical reference for final decision on choice. The military ground-attack airline is considered in the evaluation of combat effectiveness, the threat level of missile, the possibility of detection, flight time, airline length, fuel consumption and easy to fly. Therefore, in essence, the course of evaluation is a multi-objective decision problem, only a qualitative or quantitative analysis means alone is difficult to find the "best solution". In recent years, the application of multi-objective theory and method has larger development. Among them, the literature[4-9] respectively adopted the entropy theory combined with grey correlation analysis method, D-S evidence reasoning, set pair analysis theory, combined the analytic hierarchy process(AHP) and grey evaluation method, AHP and triangle fuzzy number, grey relation projection method and based on the ideal point decision methods of combination, uncertainty and ambiguity problem of processing information, sorting and optimization scheme. Although researchers have made great progress in study of algorithm, but a lot of problems exist in the practice, such as evaluating according to some special requirements. Therefore, on the basis of literature[10], this paper uses the fuzzy theory and grey theory to extend TOPSIS, in addition to solve the problems of the information uncertainty and ambiguity, also manifests the intention of commander's. The experimental results show that the method, can meet the requirements of the commander, improve the efficiency of operational decisions.

Evaluation Model

There are seven indexes to evaluate the attack airline, combat effectiveness, the threat level of

missile, the possibility of detection, flight time, airline length, fuel consumption and easy to fly.

(1) The effect of the attack by the weapons and ammunition from the attack plane[11];

$$E = e^{-\alpha t}[1 - e^{-\beta t}] \tag{1}$$
$$\alpha = \lambda p_1, \beta = u p_2$$

E is task completion rate, t is time, λ is the number of threats, p_1 is the probability of the plane destroyed by treat at once time, u is the average time for flying to attack targets, p_2 is the probability of target was destroyed by once attack.

(2) The probability of threat probability during the flight time was hit by anti-aircraft missiles[12];

$$S(A) = P_{(t>t_{fm}+t_{rm})} = \int_{t_{fm}+t_{rm}}^{\infty} \lambda_1 e^{-\lambda_1 t} dt \tag{2}$$

S(A) is the probability of plane killed by missile, t_{fm} is the time for air defense missile to intercept point, t_{rm} is the reaction time of air defense missile, λ_1 is the density of air strike at the time of air defense missile intercept.

(3) The probability of detection by radar during the flight time[13].

$$R_{max} = \left[\frac{P_T G^2 \lambda^2 \sigma}{(4\pi)^3 k T_0 B_n F_n \left[\frac{S}{N}\right]_{min} L}\right]^{\frac{1}{4}} \tag{3}$$

P_T is radar transmit pulse power, G is radar antenna gain, λ is the wavelength of radar, σ is RCS, k is the constant of Pohl Seidman, T_0 is working noise temperature, B_n is noise bandwidth, F_n is noise figure, $(S/N)_{min}$ is the minimum signal to noise ratio required for the detection of the input end of the detector, L is total loss coefficient.

If the electromagnetic jamming is considered, the radar detection range is calculated.

$$R_t = \left[\frac{P_t G_t^2 \sigma K_r}{4\pi B_r \frac{S}{J} L_r} \sum_{j=1}^{n} \frac{R_j^2 B_j L_j}{P_j G_j(\theta) G_r(\varphi) \gamma_j}\right]^{\frac{1}{4}} \tag{4}$$

K_r is the factor of radar anti-jamming, （S/J）is SIR, R_j is the distance between the jamming and the radar, L_j is system loss of the jamming machine, γ_j is the polarization loss of interference signals on the radar antenna, $G_j(\theta)$ is the gain of the jamming machine in the radar direction, $G_r(\varphi)$ is the gain of radar antenna in the direction of the interference machine. θ is the interfering direction and the angle between the interference of the machine and the radar line, φ is the angle between the main lobe of radar and the connection between radar and jamming machine. The relationship between radar detection probability and distance is:

$$P = \frac{R^4}{r^4 + R^4} \tag{5}$$

P is radar detection probability, R is radar detection range, r is the distance between target and radar.

(4) The time duration of the flight;

(5) the length of the airline;

(6) The fuel consumed during the flight [14];

$$W = w_1 t_1 + w_2 t_2 + w_3 t_3 + w_4 t_4 \tag{6}$$

There are great differences in the characteristics of different flight phases of flight aircraft, fuel consumption characteristics are not the same. The flight stage is divided into 4 stages: sliding, climb, cruise and fall. The fuel consumption in each stage is obtained by stage of flight time multiplying the average consumption.

(7) The difficulty of airline flight control, such as low-altitude flying, the difficulty is high value, high-altitude flying , the value is not high.

The evaluation methods of airline is: 1) The airline requirements for airline was converted to the normalized triangular fuzzy number of weights; 2) Standardized the indexes of airline evaluation, then according to normalized weights, assembled the fuzzy weights; 3) used the gray correlation to measure the degree of positive and negative ideal solution close to the current airline, with extended TOPSIS method. 4) Finally, according to the close degree of each airline to sort, then got the best airline.

The Example Analysis

Assuming that the air force command post accept the task to attack enemy radar station. Through situation analysis and airline planning system developed 4 airlines. The specific evaluation process is as follows:

(1) Determine the fuzzy weights of evaluation indexes, the table 1 is the three advices to index of evaluation. And then converted into triangular fuzzy Numbers, as shown in table 3.

Tab.1 Evaluation Weight Table

The evaluation index	Advice 1	Advice 2	Advice 3
combat effectiveness	more important	important	more important
the threat level of missile	important	important	very important
the possibility of detection	no important	no important	more important
flight time	more important	More important	no important
airline length	more important	More important	more important
fuel consumption	little important	little important	no important
easy to fly	more important	no important	more important

(2) Through the simulation system to evaluate airline, evaluation data of decision matrix (table 2), after standard data processing here are standardized decision-making matrix A:

Tab.2 Evaluation Parameters

The evaluation index	airline 1	airline 2	airline 3	airline 4
combat effectiveness	0.3	0.8	0.7	0.9
the threat level of missile	0.7	0.9	0.8	0.8
the possibility of detection	50	500	600	700
flight time	6	10	2	2
airline length	20	50	15	17
fuel consumption	3	30	20	24
easy to fly	4	20	30	40

(3) Calculating relative solution of fuzzy grey correlation degree and degree of grey incidence is relatively close to, as shown in table 3.

Tab.3 Close degree Sort Table 1

airline	Fuzzy closeness	Close degree
airline 1	(0.4870,0.5009,0.5102)	0.4993
airline 2	(0.5403,0.5339,0.5311)	0.5351
airline 3	(0.5072,0.5037,0.5025)	0.5045
airline 4	(0.4801,0.4698,0.4622)	0.4706

Calculation results as shown in table 6, according to the close degree of grey relation , the order of the four schemes is: airline 2> airline 3> airline 1> airline 4. From the weight of evaluation index table (table 2) can be seen in: " the threat level of missile " and " combat effectiveness " weight is bigger, the calculation results accord with expert preferences.

If the combat mission has strict limits to the time, you can modify the table 2 " fuel consumption " in the three experts as "very important". After a recount of the fuzzy grey correlation degree and grey correlation degree as shown in table 7. The order changes accordingly, airline 1 > airline 2 > airline 3 > airline 4. Can be seen from table 4, airline 1 "fuel consumption" is the smallest.

Tab.4 Close Degree Sort Table 2

airline	Fuzzy closeness	Close degree
airline 1	(0.5116,0.5144,0.5182)	0.5147
airline 2	(0.5048,0.5097,0.5153)	0.5099
airline 3	(0.4975,0.4983,0.4992)	0.4983
airline 4	(0.4855,0.4775,0.4684)	0.4771

Conclusion

By integrating fuzzy theory and grey system theory and method of multi-objective decision-making theory effectively solve the fuzziness and uncertainty of combat command decision making problems. Through examples proved that this method is validity and feasibility, can shorten the decision-making time, improve the efficiency of command.

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