MATEC Web of Conferences **114**, 03015 (2017) DOI: 10.1051/matecconf/201711403015
2MAE 2017

Research and Simulation on Division Attack Airspace

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Abstract. Division attack is the basic tactical action of air strike operation carried out by the Air Force. The aircraft tactical action model is analyzed and established according to the Division attack pattern. Track points are determined on the basis of parameters of the weapons, and the ideal trajectory is determined under the constraint of the flights' ideal parameters and the type of target. The upper winds and pilot' operating error are taken into account on the ideal track, and the total deviation is calculated. We put forward a method of establishing airspace based on the probability deviation of the attack track, and adopt the relevant flight data to carry on the simulation verification. The final results show that the effectiveness and practicability of this method, and it is helpful for the rapid generation of relevant airspace.

1 Introduction

Implementing air raid operations, There may be some weapons such as the Aviation of Air Force, the Long Range Artillery of Army, the ship - to - ground missiles of Navy, the cruise missiles, the Tactical Missiles of Rocket Force require to use a certain airspace in the attack process[1-2]. If we can't plan the airspace before the combat for a reasonable allocation, it will lead to conflict of airspace, and even appears accidental injury.

At present, there are many literatures on airspace planning at home and abroad, but mostly concentrated in the civil aviation airspace, and less on the military. In 2011, Jia Linsheng plans airspace for early warning based on the patrol routes of early warning aircraft, and analysis the early warning effectiveness according to different positions of early warning aircraft in the air line. In 2014, Chen Yunxiang determines the patrol boundary according to the target airspace to be detected and security requirements for early warning aircraft, and then determines the center point and size of patrolling airspace within the patrol boundary. But the airspace on fighter is also basically focused on training airspace, fuel airspace and other non-combat airspace. While the research and planning for air-raid operational airspace is lagging behind.

Due to the particularity of the cooperation, the attack airspace should contain the flight path, attack area of target and the necessary safety separation. This paper references the method which plans airspace based on airline in literature [3]. Aiming at the mode of diving attack in air-raid operation, the attack track model is established. The factors of airborne wind and pilot error are added into the ideal track. The maximum deviation of track is determined. Finally, the safe separation is joined and the airspace module is built [4].

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2 Diving Attack Path Planning

Implementing dive attacks usually involves adding tactical maneuvers to avoid enemy's missiles or radar threats [5]. The basic track is shown in Figure1.

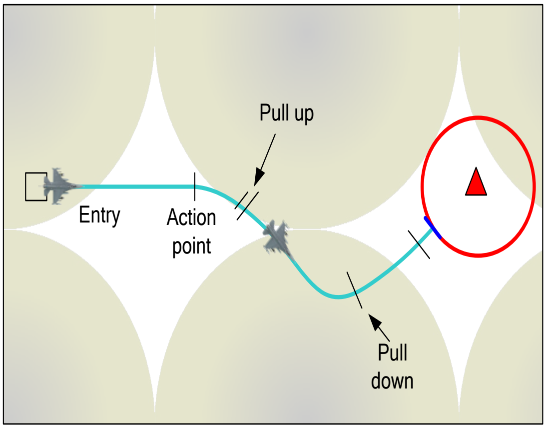

Figure1. Diving Attack Path

Before implementing an air-raid operation, the mission trajectory is generally planned to determine the specific points and parameters in the flight path. The track planning steps are as follows:

Step1: Determine the position of the target point;
Step2: Select the appropriate ammunition to determine the bomb height and bombing distance;
Step3: Select the appropriate dive height;
Step4: Determine the entry point position;
Step5: Determine the safety separation.

3 The motion model of Fighter

In order to simplify the calculation, the geodetic coordinate system as shown in the figure is established. Only the speed, pitch, slope, tangential overload and normal overload are taken into consideration. The aircraft motion model is constructed without considering the aircraft inertia, angle of attack and angle of attack. As shown in Figure.2.

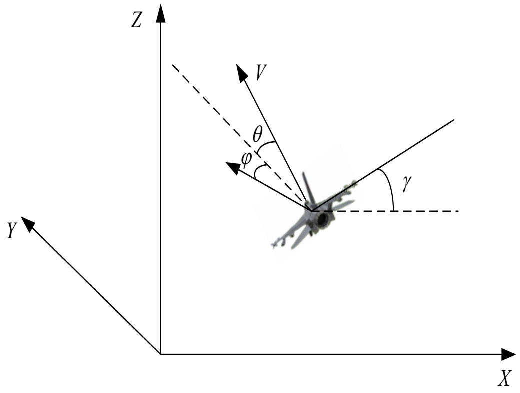

Figure2. The motion model of Fighter

The kinematic equation is as follows:

$$\begin{cases} \dot{x} = v\cos\theta\cos\varphi \\ \dot{y} = v\cos\theta\sin\varphi \\ \dot{z} = v\sin\theta \\ \dot{v} = g(G_x - \sin\theta) \\ \dot{\theta} = g(G_f\cos\gamma - \cos\theta)/v \\ \dot{\varphi} = -gG_f\sin\gamma/(v\cos\theta) \end{cases} \tag{1}$$

v is the true speed, g is gravitational acceleration, θ is pitch angle, γ is slope, φ is course angle, G_x is tangential overload, G_f is normal overload.

4 Analysis flight errors

Before the implementation of air-raid operations, the task category, aircraft type, flight action have been identified, this paper only consider the stand-alone situation, and discuss these uncontrollable factors include the pilots technical level and air wind.
The fighter lateral offset is calculated as follows:

$$X_p = X_c + E_\alpha \tag{2}$$

Among them, X_p is the total offset of the aircraft, X_c is the offset caused by pilot error, E_α is wind deviation.

4.1 Winds

The omnidirectional wind specified by the ICAO is used to describe the error. The wind spiral can quantify the effects of wind on the airplane during the turn and maximize it. Therefore, this paper takes this method into the airspace planning of air-raid operation. The wind spiral is shown in Figure.3.

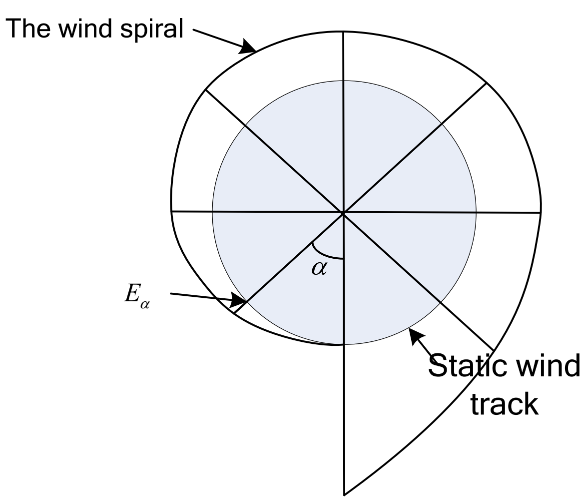

Figure3. The wind spiral

The influence formula of wind:

$$E_\alpha = \left(\alpha / \omega\right) \times \left(v_{wind} / 3600\right) \tag{3}$$

In the formula: E_α is drift distance, α is turning angle, ω is turning angular velocity.

4.2 Pilot operating error

In this paper, the civil aviation flight error is taken as a reference, the operational error of the fighter pilots is considered as Gaussian distribution [6] based on the ideal operation.

$$W \sim N\left(W_0, \sigma_W^2\right)$$
$$f(W) = \frac{1}{\sqrt{2\pi}\sigma}\exp\left(-\frac{(W-W_0)^2}{2\sigma^2}\right) \tag{4}$$

Among them: W_0 is ideal operation, W is actual operation, σ is standard deviation, the value refer to references [6].

Since the normal distribution value is infinity range from the positive to negative, and when the pilot operates the aircraft, the operation error will not tend to be infinite, in order to reflect the two points, the normal distribution of the distribution function is truncated, the truncation points[7-8] is $(\mu - 3\sigma)$ and $(\mu + 3\sigma)$, That is, the probability is 1 in this interval.

According to the probability distribution $P = \int_{-x_1}^{x_1} f(W)\,dx$, determines the effective probability P, and then the maximum value of the error can be calculated.

Total error can be calculated according to the above operational error model:

$$X_C = \sum_{j=1}^{m} X_j, j = 1, 2, \cdots \tag{5}$$

5 Simulation Study of Example

Due to the particularity of military flight, this paper takes civil flight data [9-10] as reference, simulated in Matlab 8.0.

The simulation results are shown in figure.4.

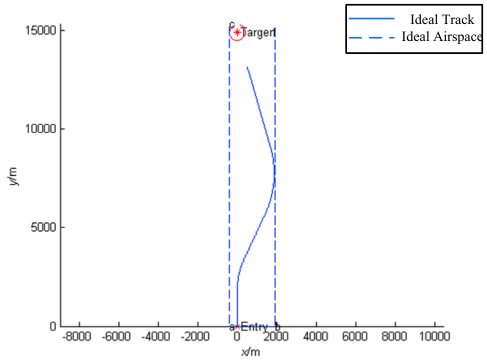

Figure4.(a) Top view of ideal airspace

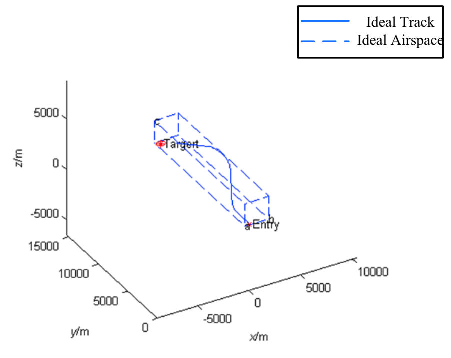

Figure4.(b) Top view of ideal airspace

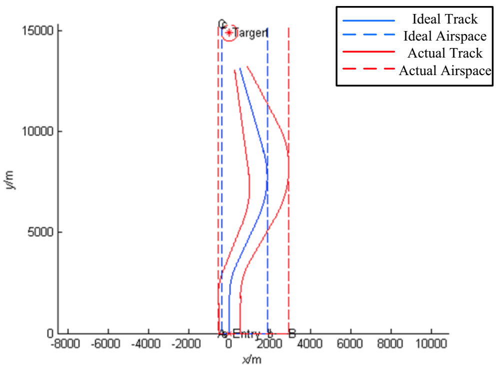

Figure4.(c) Top view of actual airspace

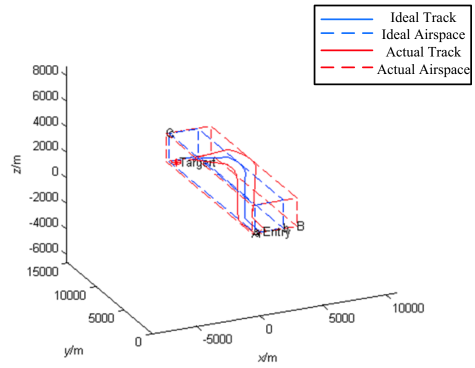

Figure4.(d) 3-D map of actual airspace

In figure 4(a) (b), the blue wireframe indicates the flight path and the required airspace size under ideal conditions. In figure 4(c) (d), the red wireframe represents the maximum deviation trajectory and the actual required airspace size after adding wind and operating errors.

We can obtain the airspace's boundary according to the simulation data as shown in Table1.

Table 1. Airspace Boundary Parameters

Ideal Boundary	a	b	c
Coordinate	(-400,0,0)	(1.8982e+3,0,0)	(-400,1.5295e+4,2500)
Actual Boundary	A	B	C
Coordinate	(-576.01,0,0)	(2.9356e+3,0,0)	(-576.01, 1.5295e+4,2500)

The width of ideal airspace is 2298.2m, the length is 15295m, height is 2500m. But the width of actual airspace is 3511.61m, the length is 15295m, height is 2500m. We can see that the actual airspace is larger than the ideal state.

From the simulation, we can see that this method can plan airspace quickly, which has versatility and can be applied to the planning of other related airspace. At the same time, it can take the concept of modular into the planning and can be combined with other airspaces easily.

6 Summary

This paper aims at the airspace planning problem in air-raid operation, a airspace planning method based on maximum deviation of trajectory is proposed in the case of dive attack model. Based on the modeling of fighter tactical trajectory, the important trajectory point is determined according to the target attribute, the effect of wind and pilot error is added, and the airspace size is determined considering the possible region of fighter attack track. This method can be used in the modular planning of airspace, which is fast and efficient. But in the planning process it does not take the withdrawal route after the completion of the fighter attack into account, and this paper takes the wind and the pilot operating error into consideration only for the lateral yaw by a certain type of aircraft. The next step will consider the enemy radar and air defense missile deployment as well as kinds of aircrafts, and planning withdrawal airspace rationally.

Acknowledgment

This paper is supported by the National Social Sciences Foundation（16GJXXX—XXX）

References

1. JIA Linsheng, WU Wenhai, GAO Wei, WANG Junyan. Analysis on Early Warning Airspace of Airspace Patrolling Route Adopted by Foreign Airborne Early Warning Airplanes[J]. Journal of Naval Aeronautical and Astronautical University. 2011.26(1),36-40.
2. CHEN Yunxiang, ZHANG Yi, ZHUANG Jun2, CAI Zhongyi. Method on Demand Determination of Early Warning Airplane Based on Combat Direction[J]. Fire Control & Command Control. 2014,39(8),94-97.
3. JI Jun, WU Feng, MA Pei-be, SUN Xiaoshu. Research on the Patrol Region Dimension Disposition of AEW in Long-range Air Defense Operation of Carrier Formations[J]. Command Control＆Simulation. 2014.36(1),78-83.
4. YU Lung. XING Changfeng. SHI Zhansong. Modeling of Airspace Resource for Cooperative Air-defense Operation[J]. Journal of Naval University of Engineering. 2014.26(1),54-59.
5. HUANG Da, CHEN Jing, REN Min. Research on Trajectory Generation of Air-to-surface Attack Based on Constraint Model [J]. Computer Simulation. 2010.27(6),74-78.
6. XUE Hongtao, SHEN Lincheng. Flight Maneuverability Analyze and Computation of Combat Aircraft Weapon Delivery Tactics[J]. Command Control & Simulation. 2010.27(6),74-78.
7. International Civil Aviation Organization, Doc 8168, Part I — Section 2, Chapter 2, I-2-3-4[S], Montreal: International Civil Aviation Organization, 2008.
8. ZHAO Yifei, WANG Chen, WANG Hongyong. Research on laws of flight path error distribution based on ADS-B[J]. JOURNAL OF CIVIL AVIATION UNIVERSITY OF CHINA. 2012.30(6),48-52.
9. ZHAO Hongsheng, XU Xiaohao, LI Rui, XIONG Zhiyong, LI Dongbin. Overview of research on flight technical error estimation in performance based navigation[J]. Journal of Traffic and Transportation Engineering. 2014.14(5),101-110.
10. Xu Xiaohao. Theoretical Method Research of Safety Separation for Air Traffic[M]. Civil Aviation University of China. 2004.12.