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A Compound Control Algorithm with Complex System

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Abstract: The controller for the delay caused by the shortage of aerodynamic response is a good remedy, can quickly respond to commands for overload, and the dynamic quality is better, the ignition algorithm can effectively resist jamming performance of jet uncertain, coordination between subsystem control allocation algorithm to promote the direct force and gas the dynamic design method, which has a controller theory and engineering application of a certain reference value.
Keywords: Complex System, Compound Control, Allocation Algorithm.

1. Introduction

With the progress of science and technology, the performance of anti-ship missiles and all kinds of fighters and UAVs is improving (Karthikeyan and Vasuki, 2016). The power of many ballistic missiles is also increasing. Our air defense system is facing great pressure.

In the past, the ship based air defense missile was controlled by aerodynamic force only, and the missile's control was affected by deflecting the rudder surface, which affected the accuracy and range of the missile's interception (Butt and Akram, 2016). About the difficult problem of aerodynamic control of compound control missiles, the relevant scholars in the world have not done much research, and have achieved some results in general.

However, most of them are theoretical exploration. In this paper, a model of attitude control compound control missile is established, and a design method of control system based on fuzzy control theory is proposed, such as ignition algorithm and control allocation algorithm, which lays an important foundation for missile simulation experiment and application.

2. A Mathematical Model for the Establishment of a Composite Control Missile

2.1 The Simplified Model of the Pitching Channel

The application of the missile is similar to the one of ERINT interceptor. By using the axisymmetric design, two pairs of all moving pneumatic rudders are set up at the end of the missile, and the attitude control engine is placed at the front of the center of mass, and the terminal is started to intercept. The direct lateral force is generated and the control torque is provided. When the attitude control engine is ignited, the lateral jet flow and the lateral flow field produce the interference effect of the jet.

Interference is more complicated, it is difficult to establish a mathematical model of precise, but in the design of control system, the influence of additional interference effect and the moment of general concern of the jet, which can be used on jet thrust amplification interference factor is described, the configuration parameters of sub thrust amplification for main engine and missile related, in addition flight height, angle of attack, and Maher number, the twist angle of airflow, the general engineering application of wind tunnel test and CFD to get.

In the short term mode, missile Maher number, height does not change, because the missile terminal guidance of the longitudinal plane periodic motion, Qiemo guidance is relatively short, so the speed and quality of the missile as a constant, without considering the additional torque asymmetry and elevator configuration, establishes a mathematical short pitch channel model:

$$\begin{aligned}\dot{\alpha} &= \omega_z - \frac{1}{mV}\left(Y^{\alpha}\alpha + Y^{\delta_z}\delta_z + K_F F\cos\alpha\right)\\ \dot{\omega} &= \frac{mVM_z^{\alpha} - Y^{\alpha}M_z^{\dot{\alpha}}}{J_z mV}\alpha + \frac{mVM_z^{\delta_z} - Y^{\delta_z}M_z^{\dot{\alpha}}}{J_z mV}\delta_z + \frac{M_z^{\omega_z} + M_z^{\dot{\alpha}}}{J_z}\omega_z + \frac{mVl_T - M_z^{\dot{\alpha}}\cos\alpha}{J_z mV}K_F F\end{aligned} \tag{1}$$

$$\begin{cases}\dot{x} = -V\cos\gamma\\ \dot{y} = -V\sin\gamma\end{cases} \tag{2}$$

$$\begin{cases} \dot{R} = -V\cos(\lambda - \gamma) \\ R\dot{\lambda} = V\sin(\lambda - \gamma) \end{cases} \quad (3)$$

$$z_1 = R - \frac{1}{2}\dot{V}_{\max}(t_f - t)^2 - V(t_f - t) \quad (4)$$

Where *M* represents the missile quality, *V* is the speed of *S* is pitching rudder angle, a's angle of attack, *F* is the nominal thrust missile engine, J_z missile is around / axis of inertia; Omega 2 missile / around the shaft angle rotate speed, l*T* is from the engine to the centroid distance parameter of *Y* and *M*; on behalf of the pneumatic.

2.2 Control Strategy of Missile

The high mobility of air defense missile general application of overload control mode, the autopilot will track the output from the system overload command related, can be transformed into an affine nonlinear mode, the control system is designed in the parameter change and continuous jet interference, design control quantity effect meet the standard system, and ensure the the reliability of the system (Pahlavani, 2017). The aerodynamic force and the direct force are two very different control volumes, and the design difficulty is relatively large (Ye and Hu, 2016). So the system is divided into two subsystems: the direct force subsystem and the aerodynamic subsystem.

Because the control of aerodynamic force has a relatively mature algorithm research, this paper focuses on the direct force subsystem. In addition, in order to prevent the coupling of the two subsystems, the engine in the case of repeated ignition or high frequent rudder angle of shock, should be the design control allocation algorithm system make the real-time distribution of the two permissions. The schematic diagram of the missile compound control is as follows.

3. The Specific Design of the Control System

3.1 Basic Principle of Adaptive Domain Adaptive Control

The conventional fuzzy control system can be expressed as a n element interpolation function

$$z(x_1, x_2, ...x_n) = \sum_{j=1}^{m}\prod_{i=1}^{n} A_{ij}(x_i)z_j \quad (5)$$

The variable universe fuzzy control mode mainly refers to the factors that make relevant transformation of the universe based on the fuzzy rule number and the fixed way, so that the scope of the universe can be adjusted automatically according to the change of input quantity, so as to achieve the purpose of precise control (Perrott, Lisa, Mack, Samar, Vannest, 2016). The increase of the domain contraction is equivalent to the number of rules, from the control point of the desired controller is closer, the actual level is low, so the accuracy of the premise to enhance control and save a large computational cost. When applying this fuzzy control theory, the expansion factor should conform to the relevant criteria such as monotonicity, duality, coordination, avoidance and normality.

3.2 Fuzzy Ignition Algorithm

For example, in the process of designing the pitching channel, we choose two input and single output fuzzy control devices. The input volume is mainly based on the error and the change of error in the overload tracking of the pitching channel, and the output is the continuous thrust of the engine. Considering the control accuracy and computation complexity, performance standards with reference to the foreign advanced overload response compound control missile actual performance and missile design, combined with the motion performance target, using symmetric triangular membership function, so that each fuzzy subset of uniform layout in the domain. The form of this function is simple and easy to calculate, which meets the requirement of the rapid response of the composite control missile. In view of the speed of tracking, the reduction of overshoot, and the saving of fuel, a related fuzzy criterion table is set up. To obtain a smooth output of the missile and ensure stability, finally output the enclosed area of the center of gravity as actual numerical reasoning, can refer to the membership function curve and the abscissa of the same, the yaw channel can be used similar fuzzy control algorithm, and then the channel tracking overload command.

3.3 The Expansion Factor of the Selection Domain

At this stage, the variable universe fuzzy control factor does not determine the consistency selection method. In order to improve the performance of the control system, we can combine the actual effect of error en

and the rate of error change. The domain extension factor by en as examples, alpha (EN) and D alpha (EN) /dt to meet the following conditions: when the error is large, as long as the general control, expansion factor without rapid change, then the alpha (EN) should be close to 1, and D alpha (EN) /dt if the error is very small; small, requires precise control of the expansion factor need to decrease rapidly, then alpha (EN) should be very small, and D alpha (EN) /dt should be great. Therefore, this paper uses the following exponential function as a scaling factor:

$$\alpha(x_i) = \left(|x_i| / E_i\right)^k + \delta, (i = 1,2...)$$
$$\beta(z) = \left(|z| / Z\right)^k + \delta \quad (6)$$

The 0<k<1, after the delta is less than or equal to $\delta \leqslant$E/1000; verification, a (EN) to select the expansion factor requirements, and in accordance with the monotonicity, avoiding zero, normality, coordination, duality theory.

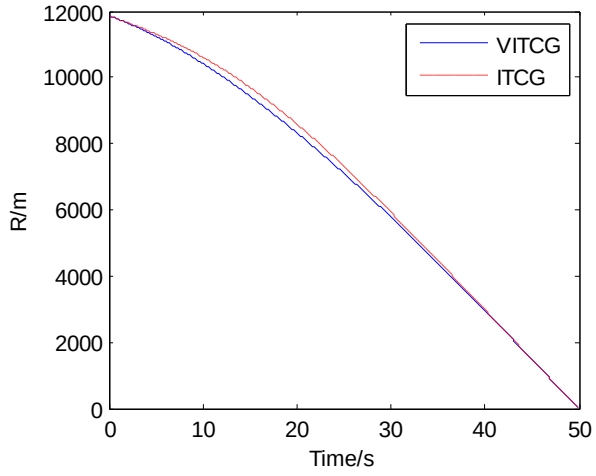
3.4 Control Allocation Algorithm

Because the R will be restricted to elastic distance measurement error and target seeker, and thus produce great instability interference, in order to improve the application performance of algorithm, can be used to design the control allocation algorithm, the basic design criteria: first, when playing to distance R by tracking deviation is very large or overload small, in order to control the application of the air force, the direct force subsystem from the relatively small value of the. At this point, the parameter k of the direct force subsystem is also very small. Secondly, when the distance between missile and target R is small or the tracking deviation of overload is very large, aerodynamic force plays an important role in order to achieve quick response and give priority to direct force control (Farraj, Hammad, Daoud and Kundur, 2016). The distribution parameters of the direct force subsystem at this time should be very large. Thirdly, the actual distribution parameters of the direct force subsystem should be increased accordingly when the distance between the projectile and the target is constantly reduced. Fourthly, when the tracking deviation of the overload is decreasing, the distribution parameters of the system should be reduced to zero.

According to the above criteria, a double input and single output fuzzy control device can be designed for two subsystems respectively. In order to facilitate the viewing of staff, the distribution principle of direct force and aerodynamic force is listed together, and the parameters of front end represent the direct force and the aerodynamic force at the rear end. The approximate method of the 2.2 section of the function of the membership degree and the method of solving the ambiguity.

The range of parameter controls the distribution of the domain: [0, 1], R domain, |E| is the most crucial parameters, can determine the direct force specific start time, the compound control of foreign missile is usually in the 0.5s 1s to start the engine, too early or too late will give the interception efficiency and accuracy great influence. In the process of design, the range of the seeker, the speed of the target and the flicker of the target angle should be fully considered.

4. Simulation



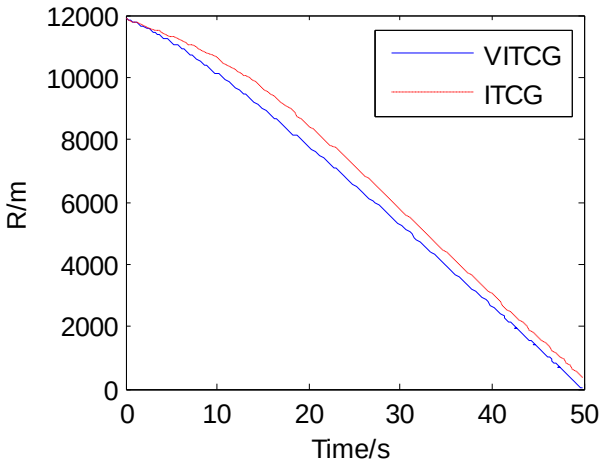


Figure 1. The missile-target relative distance

5. Conclusions

The controller for the delay caused by the shortage of aerodynamic response is a good remedy, can quickly respond to commands for overload, and the dynamic quality is better, the ignition algorithm can effectively resist jamming performance of jet uncertain, coordination between subsystem control allocation algorithm to promote the direct force and gas the dynamic design method, which has a controller theory and engineering application of a certain reference value..

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