

UAV Dynamic Simulation Model Establishment Method Based on Simulink/ Aerosim

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Abstract. Aiming at the problem of UAV dynamic modeling with high difficulty and poor timeliness, a UAV dynamic model based on Simulink/Aerosim rapid method is established in this paper. Based on the analysis of UAV system internal structure, using Simulink/Aerosim toolbox to build six degrees of freedom dynamic simulation model of unmanned aerial vehicle and the setting of relevant parameters and RTW environment configuration process is analyzed, finally, by analyzing the typical flight parameters of a certain type UAV in ideal environment and wind interference environment, the feasibility and validity of the method is illustrated.

Keywords: Simulink/Aerosim, dynamic model, flight parameters

1. Introduction

In the process of establishing the dynamic model of UAV, timeliness is a factor that cannot be ignored. Therefore, it is of great practical value to study the rapid and effective method of UAV dynamic model. Foreign Rapid Prototype Technology has been applied to flight simulation experiments. For flight dynamics models in training simulators, the accuracy of modeling is not as accurate as a research-based simulator, but is modeled difficulty and timeliness is the need to focus on solving the problem. Therefore, this paper proposes a rapid establishment method of UAV dynamic model based on Simulink / Aerosim for the problem of poor performance of training unmanned aerial vehicle, which provides technical support for the rapid establishment of aircraft system models in UAV simulation training systems^[1-2].

2. UAV Dynamic Simulation Model Development Method Based on Simulink/Aerosim

2.1 Dynamic simulation model development

UAS internal structure is as shown in Fig.1.

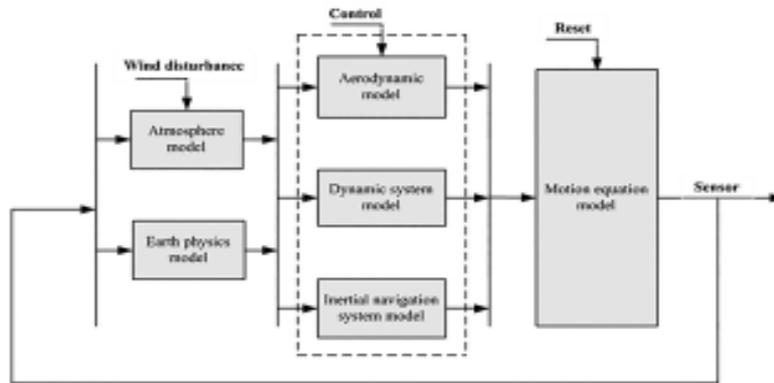


Figure.1 UAS internal structure

The system uses the Simulink / Aerosim toolbox provided by Unmanned Dynamics to build a 6-DOF unmanned aerial vehicle dynamic simulation model^[3]. UAV module and the initial value of the process shown in Fig.2.

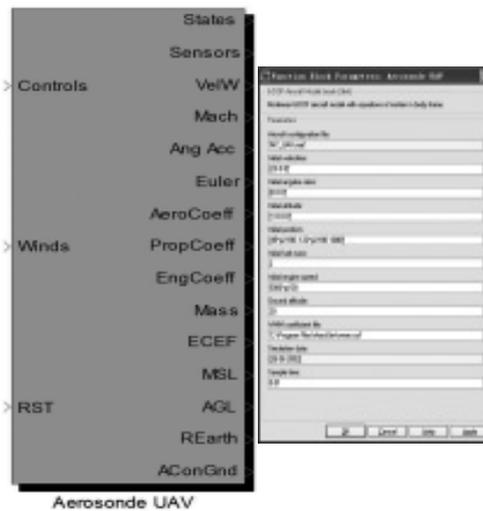


Figure.2 UAV module and its initial value set diagram

The relevant parameters that need to be configured in the modeling process include ^[4]:

① UAV parameter configuration file. Aerosim in this file default file name is template_cfg.m, this default file name to MY_UAV, in the command window to run the file MY_UAV can generate MY_UAV.mat file directly, as shown in Fig.3.

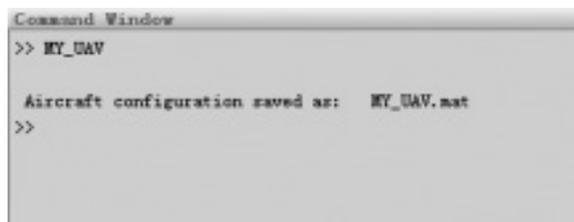


Figure.3 UAV parameter configuration file (.mat) generated schematic

② The center of gravity of the aircraft. The default aircraft center of gravity position can be considered

at the origin, for example: $rAC = [0 \ 0 \ 0]$.

- ③ Aerodynamic parameters range. In order to ensure that the aerodynamic model output is within the linear range, the range of aerodynamics must be defined. The module used here is a module in the Aerosim toolbox. To ensure the reliability of the simulation, the module must be provided under linear conditions. Accepted range of parameters (usually small angle range), mainly including airspeed, angle of attack and side slip angle.
- ④ Aircraft related pneumatic parameters. Including the mean aerodynamic chord-MAC, the wing span-b and the wing area-S.
- ⑤ Used to calculate the relevant parameters of aerodynamic coefficient and aerodynamic moment coefficient. The aerodynamic coefficients include the drag coefficient, the pitch moment coefficient and the yaw moment coefficient. The drag coefficient includes the drag coefficient, the side force coefficient and the lift coefficient.
- ⑥ Propulsion system related parameters. The propeller mounting position $rHub$, the reference position relative to the origin, the propeller range $Rprop$, and the moment of inertia $Jprop$.
- ⑦ Engine parameters. For example: Engine speed vector $RPM = [1500 \ 2100 \ 2800 \ 3500 \ 4500 \ 5100 \ 5500 \ 6000 \ 6400]$, the pressure $MAP = [60 \ 70 \ 80 \ 90 \ 92 \ 94 \ 96 \ 98 \ 100]$.
- ⑧ Characteristic height of the atmospheric data.
- ⑨ Aircraft inertia parameters and full-load moment of inertia when loading at full load, and so on, including the maximum load weight, no-load center of gravity, full load center of gravity.

Through the related parameter setting and the parameter configuration file generation, we can carry out the development of the dynamic simulation model of the specific model.

2.2 RTW development environment configuration^[5-9]

RTW as Matlab/Simulink expansion tool, it can be built by the user Simulink model to generate real-time operating system running on the executable program Shorten the UAV simulation training system development cycle^[8]. The RTW program automatically creates the following four steps:

- 1) Model analysis;
- 2) Target language compiler generates code;
- 3) Custom binding file generation;
- 4) Executable program generation.

RTW program creation is from the Simulink module analysis and establishment of the beginning, set the compiler environment, you can use the Tool | Real-Time Workshop | Build model menu to compile and connect the model, and ultimately generate executable files^[9]. The parameter setting dialog box is shown in Fig.4.

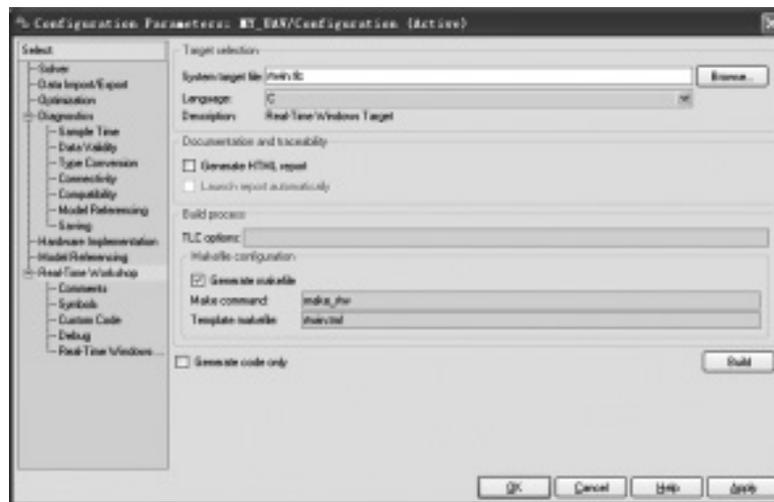


Figure.4 Parameter Settings dialog box

Click the „Browse “ option corresponding to the System target file in the parameter dialog box of Figure 4; the real-time tool target selection dialog box shown in Fig.5 will be displayed. The desired target file type can be selected, Here for the rtwin.tlc, that is, Real-Time Windows Target type.

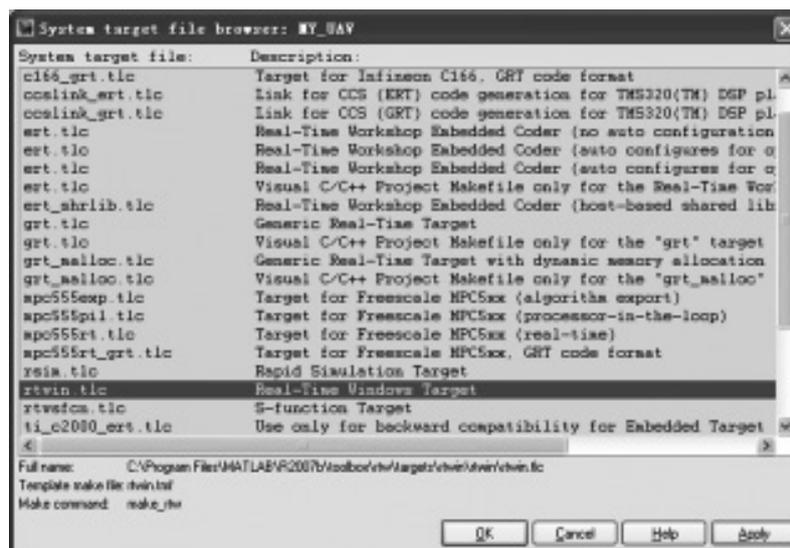


Figure.5 Real-time tool target selection dialog box

3. Typical Examples

3.1 Dynamic simulation model of typical unmanned aerial vehicle based on Simulink/Aerosim

Modify the file named Config_template.m in the Sample folder under the Aerosim installation directory. You can set the UAV model for the specific aerodynamic layout required by the user by modifying the relevant parameter values in this file. UAV initialization needs to configure the relevant parameters include:

- ① Aircraft configuration file

- ② Initial position
- ③ Initial velocities
- ④ Initial altitude
- ⑤ Initial angular rates
- ⑥ Initial fuel mass
- ⑦ Initial engine speed
- ⑧ Ground altitude
- ⑨ Sample time

Through the above parameters configuration file modification and flight simulation initial value settings, you can customize a specific model (that is, a specific pneumatic layout) of the UAV, and can set the initial value of the simulation operation.

3.2 Example simulation analysis

The structure model of the UAV flight simulation system shown in Fig.6 is constructed and simulated in Simulink/Aerosim environment for a certain type of unmanned aerial vehicle. The feasibility and effectiveness of the simulation system are illustrated by studying the typical parameters of the UAV (airspeed and 3 Euler angles) in the ideal environment (Wind[0 0 0]) and the wind disturbance environment (Wind[xyz]). The UAV parameter settings file name UAV.m, in the Matlab command window run this file UAV, and then you can generate UAV.mat file. The UAV.mat configuration file is filled in the parameter configuration file option in MY_UAV, then the parameters of the UAV will be set according to the parameters in the configuration file. The relevant parameters are set as follows:

- 1) UAV center of gravity range: $r_{AC}=[0\ 0\ 0]$.
- 2) Aerodynamic parameters Range: Airlift range $V_{aBnd}=[33\ 50]$ m / s, (aircraft flight speed range 120 ~ 180km / h) Attack angle range= $[-\ 0.1\ 0.5]$ rad, side slip angle range= $0.5\ 0.5]$ rad.
- 3) UAV related pneumatic parameters: the average pneumatic chord length $MAC = 0.54148\text{m}$, wing expansion $b = 7.5\text{m}$, wing area $S = 3.965\text{m}^2$.
- 4) Propeller installation position: $r_{Hub}=[2.1875\ 0\ 0]\text{m}$, propeller range $R_{prop}=0.94\text{m}$, propeller inertia moment $J_{prop}=0.29264\text{kg} \cdot \text{m}^2$.
- 5) take-off and no-load parameters: take the no-load the maximum quality $m_{empty}=240\text{kg}$, full load maximum mass $m_{gross}=320\text{kg}$, no load when the center of gravity $C_{gempty} = [0.156\ 0\ 0.079]$ m, full load center of gravity $C_{ggross}=[0.159\ 0\ 0.090]\text{m}$.Momentary moment of inertia $J_{empty}=[0.7795\ 1.122\ 1.752\ 0.1211]$ $\text{kg} \cdot \text{m}^2$, moment of inertia at full load $J_{gross}=[0.8244\ 1.135\ 1.759\ 0.1204]$ $\text{kg} \cdot \text{m}^2$

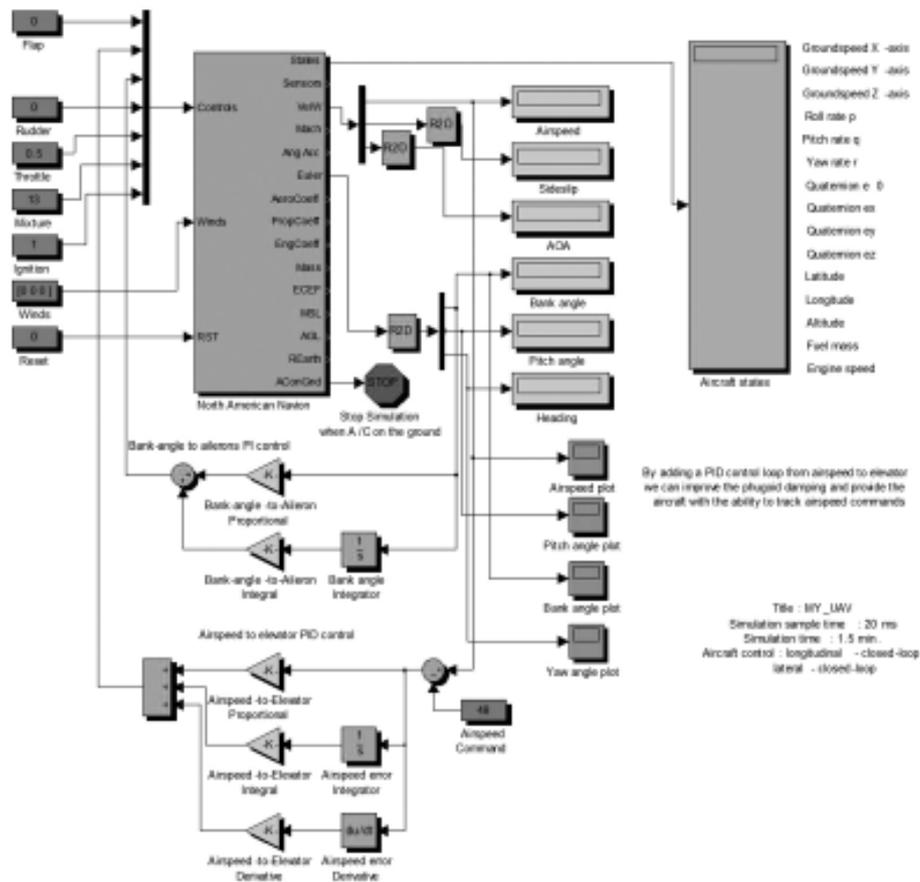


Figure.6 UAV model structure diagram

According to Fig. 6 shows the UAV model structure set the initial parameters shown in table 2.

Table 1 UAV model initial parameter value setting

label	initial value setting	parameter value
1	Initial velocity	50m/s
2	Initial angle velocity	[0 0 0]
3	Initial altitude	1000m
4	Initial position	[pi/4 -0.677/pi 1000]
5	Initial fule mass	60.5kg
6	Initial engine speed	5596 r/m
7	Initial altitude	20m
8	Sample time	50ms

To enhance the stability of the control, airspeed, tilt angle added to the PID control loop. In Winds=[0 0

0] and Winds=[5 -3 0] in two flight environments,UAV typical parameters, namely, airspeed, tilt, pitch and The output value of the flight angle is shown in Fig.7 to Fig.10.

Set the airspeed initial value of 50 m/s, the stability value of 35m/s, it can be seen from Fig.7 that the velocity value of the UAV is gradually stabilized to 35m/s after 20s or so, with the ideal environment (Wind = [0 0 0]) and the wind disturbance environment Wind = [5 -3 0]). In the wind-disturbing environment, the velocity fluctuates above the steady value (35 m/s), which is closer to the actual airborne; It can be seen from Fig.8, after 20s or so, UAV tilt angle from -0.8° gradually become 0° , that is, unmanned aerial vehicles from the tilt state to the horizontal state; It can be seen from Fig.9, after 20s or so, the aircraft's pitch angle stabilized to about 13° , that is, the aircraft is doing climbing movement; It can be seen from Fig.10, after 20s or so, the aircraft yaw stability 0° (ie 360°) or so, that is, the plane is doing direct flight.

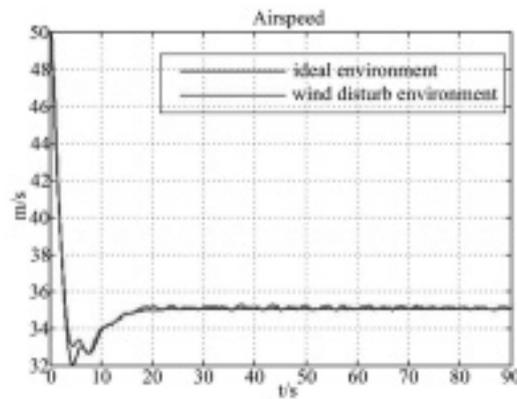


Figure.7 Airborne output of UAV in two flight environments

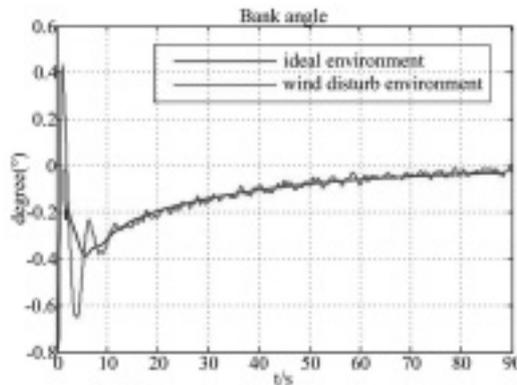


Figure.8 Unmanned aircraft tilt angle output in both flight environments

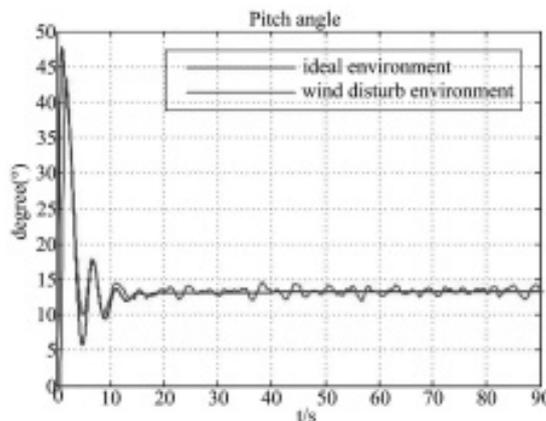


Figure.9 UAV pitching output in both flight environments

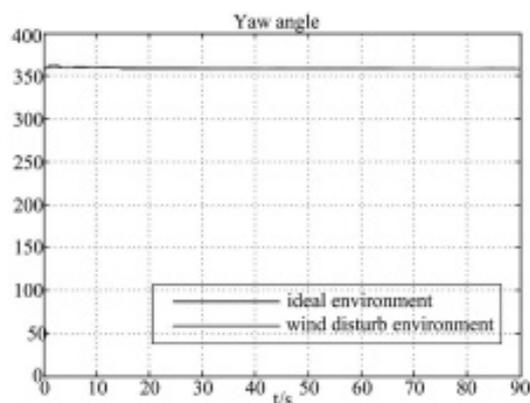


Figure.10 UAV yaw angle output in both flight environments

The simulation results show that the output of UAV typical flight parameters can not only meet the demand of UAV dynamic modeling, but also improve the efficiency of the whole system. The method is based on the dynamic model of UAV To the unmanned aerial vehicle flight simulation system engineering has important application value.

4. Conclusion

In this paper, aiming at the actual modeling requirements of UAV dynamic model, a fast integration model of UAV simulation model based on Simulink/Aerosim is proposed. Based on the analysis of the internal structure of the UAV system, the relevant parameters and the development environment configuration method of the modeling process are analyzed, and the simulation analysis is carried out with a specific aerodynamic layout of the UAV as an example. This method can meet the demand of UAV dynamic modeling, and can effectively improve the development efficiency of the whole flight system, and has certain application value.

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