Small Unmanned Aerial Vehicle Simulation Research

Shaojia Ju[1, a] and Min Ji[1, b]

[1]Xijing University, Shaanxi Xi'an, 710123, China

[a]E-mail:2571449451@qq.com, [b]E-mail:995010771@qq.com

Keywords: UAV; Vehicle; Simulation

Abstract. This article from the uav model accuracy, real-time and functional aspects of software of software in the loop simulation software based on PC and semi-physical simulation based on the target software research, validation, and verification results are analyzed.

Introduction

Uav six degrees of freedom nonlinear model in simulation software must be accurate and reliable, true and accurate to describe the dynamics and kinematics characteristics of the unmanned aerial vehicle, reflect the status of the uav flying in the sky, meet the precision requirement, so we must verify the accuracy of the simulation software of unmanned aerial vehicle model. Respectively the software in the loop simulation software and semi physical simulation software drones nonlinear model and compare the Simulink model, analysis its accuracy meets the simulation accuracy required.

Model

Simulink mathematical model and the above two goals for unmanned aerial vehicle simulation software of initial value of unmanned aerial vehicle model to set the same flight, and give the same actuator control information, operating model, the comparison results as shown in Fig. 1-6.

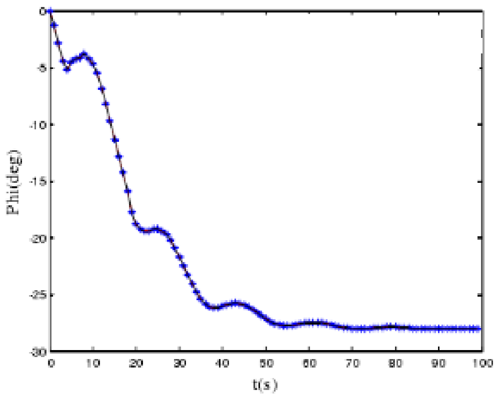


Figure 1. The horizontal lateral roll angle

From Fig. 1 shows, the software in the loop simulation software and semi physical simulation software of unmanned aerial vehicle model and the mathematical model of unmanned aerial vehicle Simulink roll Angle curve overlapping consensus, drawing its error curve as shown in Fig. 2 and Fig. 3.

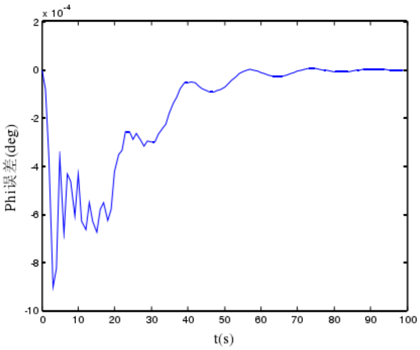


Figure 2. The software in the loop simulation roll Angle error of

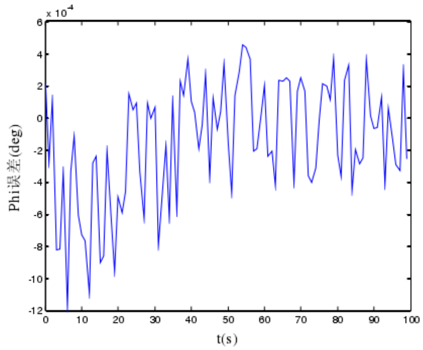


Figure 3. Semi physical simulation software software roll Angle error

Fig. 2 and Fig. 3 show the software in the loop simulation software and semi physical simulation software of unmanned aerial vehicle model and the mathematical model of unmanned aerial vehicle Simulink roll Angle error between 10-4 orders of magnitude.

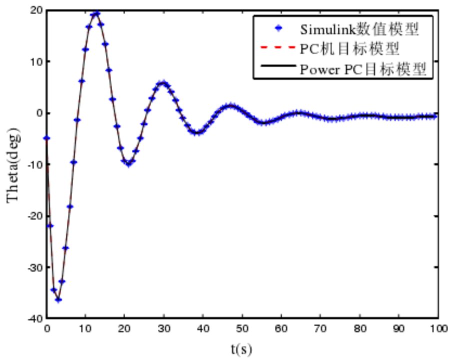


Figure 4. The longitudinal pitching Angle contrast

Fig. 4 shows the software in the loop simulation software and semi physical simulation software of unmanned aerial vehicle model and the mathematical model of unmanned aerial vehicle Simulink pitching Angle curve overlapping, drawing its error curve as shown in Fig. 5 and Fig. 6.

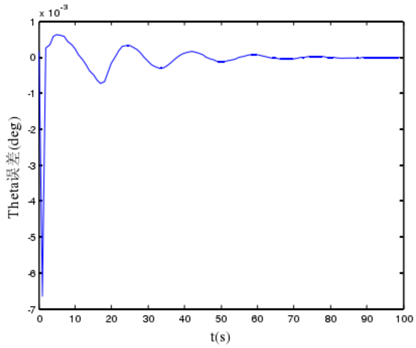


Figure 5. The software in the loop simulation software pitching angle error

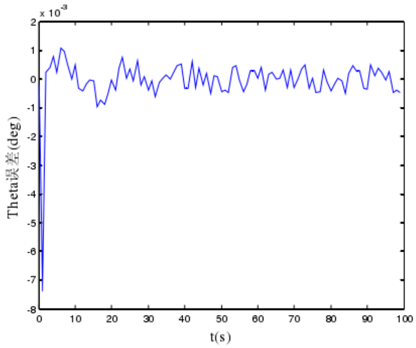


Figure 6. A half physical simulation software pitching angle error

By Fig. 5 and Fig. 6 show the software in the loop simulation software and semi physical simulation software of unmanned aerial vehicle model and the mathematical model of Simulink pitching angle error between 10-3 orders of magnitude. Comprehensive comparison above shows, RTW generated model and Simulink model operation result are consistent, roll Angle error between 10-4 orders of magnitude, pitching Angle error between 10-3 orders of magnitude, in the range of allowable error, meet the requirements of uav simulation precision, RTW generated by the model is accurate and reliable.

Real-time Software Validation

A primary requirement of real-time simulation is must satisfy the real-time performance of the simulation, to ensure the real-time simulation software running, including in PC software in real-time simulation and target machines in the real time semi physical simulation, so must be validated the simulation software of real-time. Validation protocols is: statistical software in the loop simulation software and software execution frequency of each task in the semi-physical simulation, determine whether consistent with the design of frequency, the simulation software of real-time.

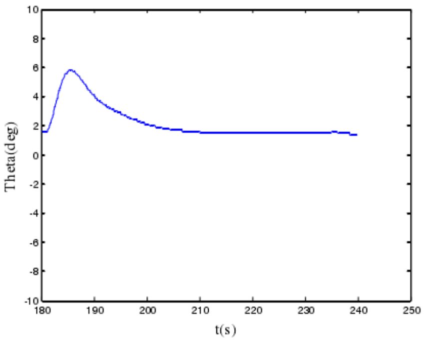
In the Loop Simulation Software

On model accuracy of simulation platform and software real-time validation, need to verify the overall performance of the simulation platform. Access to the flight control computer hardware devices, such as structures, unmanned aerial vehicle flight control system simulation architecture, the software in the loop simulation experiment was carried out respectively, and the status of unmanned aerial vehicle flight simulation, analyzes the results conform to the design requirements. Hardware in loop real-time simulation software connection as shown in Fig. 7, the software in the loop simulation software and the simulation console software running on the same PCS.

Figure 7. Hardware in loop real-time simulation software

1) Instructions navigation

Make the unmanned aerial vehicle work in instruction navigation mode, separately send unmanned aerial vehicle climb, down, left, right plate, such as instruction, from two aspects of vertical and horizontal lateral uav flight control of instruction navigation mode for validation. State of flight simulation data as shown in Fig. 8-9.



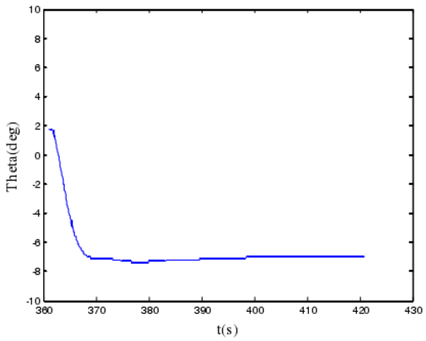


Figure 8. Climb instruction mode pitching angle

Figure 9. The sliding state pitching angle under instruction

From Fig. 7-9, based on the PC software in the loop simulation flight is normal, command response accurately, and the curve is smooth, smooth flight status.

2) Autonomous navigation

Make the unmanned aerial vehicle work in autonomous navigation mode, realize the whole process of unmanned aerial vehicle flight. Unmanned aerial vehicle flight data as shown in Fig. 10.

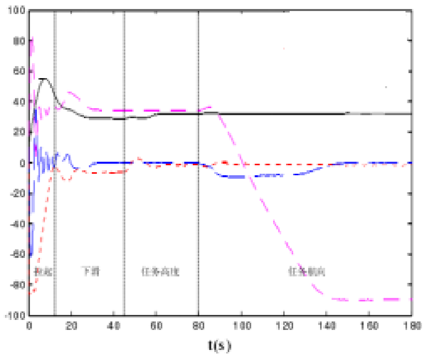


Figure 10. The whole process of autonomous flight

As shown in Fig. 10, unmanned aerial vehicle in 0 ~ 13 s s gesture, 13 s ~ 45 s into the decline stage, 45 s ~ 80 s task height, 80 s ~ 180 s heading to task. In the process of the whole autonomous flight, unmanned aerial vehicle control logic to perform accurate, flight status, comply with the design requirements, verify the software in the loop simulation software is accurate and reliable.

Flight Gear Visual Simulation

Unmanned aerial vehicle for real-time simulation, simulation software state data or other information of the unmanned aerial vehicle in accordance with the FGNet FDM class format packaging, sent via UDP network protocol to Flight Gear visual simulation module, by Flight Gear to three dimension visual display on the screen, as shown in Fig. 11.

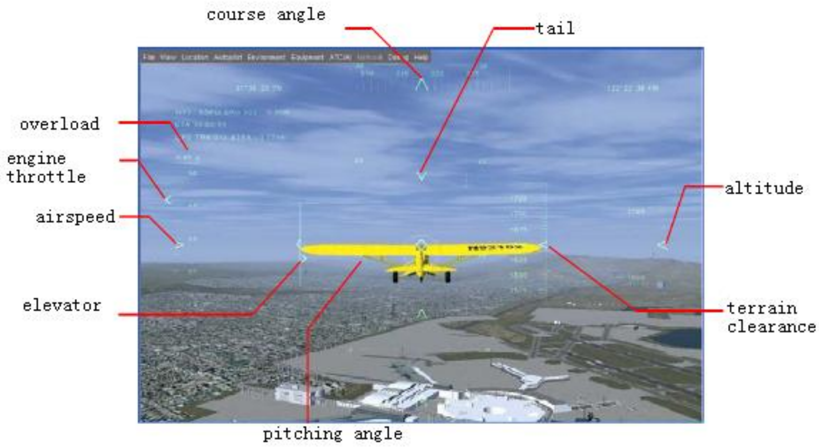


Figure 11. Flight Gear visual simulation

As shown in Fig. 11, Flight Gear visual simulation module in the form of three dimension visual display in the process of unmanned aerial vehicle Flight attitude Angle, state information such as height, overload, airspeed and rudder surface, such as engine control information, the simulation effect is clear, can visually describe unmanned aerial vehicle flight status, the development and validation of uav Flight control system plays an important role.

Summary

This article from the model precision, real-time software and functional aspects of software based on PC in the loop simulation software and semi-physical simulation based on the target software verification and testing, validation results show that the uav model precision, good real-time, unmanned aerial vehicles based on RTW rapid prototyping simulation platform to achieve the system design target, meet the design requirements, can be used for unmanned aerial vehicle flight control system of real-time simulation.

References

[1] John Öström. Developing a Low-Cost Flight Simulation to Support Fatigue Analysis. AIAA 2004-5161.

[2] Eric N. Johnson, Sumit Mishra. FLIGHT SIMULATION FOR THE DEVELOPMENT OF AN EXPERIMENTAL UAV.AIAA 2002-4975.

[3] Hong Chul Yang, Belal Sababha, Coskun Acar, et al. Rapid Prototyping of Quadrotor Controllers using MATLAB RTW and ds PICs. AIAA 2010-3407.

[4] David M. Christhilf. Simulink-Based Simulation Architecture for Evaluating Controls for Aerospace Vehicles (SAREC-ASV). AIAA 2006-6726