

## Design of semi-physical simulation system of UAV based on computer control

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**Keyword:** UAV, flight control system, semi-physical simulation system.

**Abstract.** For a fly control system of UAV, the author designs the hardware in the loop simulation system, formulates the construction and working theory of it, and introduces the formulation software. The results shows that, the system can supply the good simulation circumstance for this automatic pilot, save the cost and the time. Especially, it is of significance to evaluate the fly quality and accelerate the research progress of UAV.

### Introduction

With the development of science technology and changes in military strategic thinking, UAV has a great application in the military, civil and other areas. The expander of application scope put forward higher requirements for UAV and the flight control system, which as the "heart" of the UAV, has also been more and more attention.

The flight control system is the core system of UAV, it is a integrated system of high-performance self-navigation, automatic flight control and task management [1]. The flight control system, which achieved all the functions of flight, also responsibly to monitor and control the subsystems of the UAV, command UAV to achieve the scheduled tasks.

The successful task been achieved by UAV depends on the performance of the flight control. UAV task depends critically on the success of the flight control system performance. Therefore, we designed a semi-physical simulation system design of UAV based on computer control. It can not only simulate all the functions such as dynamic characteristics, input and output signals and electrical physical properties of the flight control, but also satisfy the design and verification requirements of the flight control through the dynamic flight of semi-physical simulation system.

### The composition of semi-physical simulation system

The semi-physical simulation system of UAV based on computer control is composed of simulation computer, sensors, flight control computer, actuator and three-axis flight simulation rotation stand. The mathematic model, system model, simulation environment model, external interference model and other models of flight dynamics of UAV can be calculated in simulation computer. The drive signals produced by simulation environment model will control the three-axis flight simulation rotation stand. The dummy environment which is used by sensor measurement is formed by the movement of the rotation stand. The flight control computer is used to collect the information of dummy flight and calculate the rule of flight control. The position signal of actuator is adopted by simulation computer through A/D. The structure of system is shown in Figure 1.

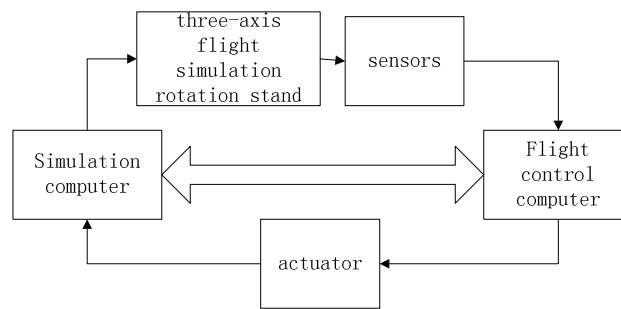


Figure1. The structure of system

**The semi-physical simulation computer.** The speed, accuracy, flexibility and economy are the main requirements of a semi-physical simulation computer. The semi-physical simulation computer is demanding because of its real-time characteristics, assuming the requirements of flight dynamics equations and the simulations of various real flight environments. The semi-physical simulation computer is used to converse and transfer signals with other physical equipment such as D/A, D/D and on-off quantity[2]. On the other hand, it is used to calculate the mathematical model, system model, simulation environment model, external interference model and other models and display the real-time simulation figures.

**The three-axis flight simulation rotation stand.** The three-axis flight simulation rotation stand, which can living and repeated the three-axis pose sky borne movements under foot, is a simulation equipment that can simulate running with three-axis in air in man-made conditions in the laboratory in order to reproduce the flight control characteristics.

The simulation computer outputs three pose angles to the servo system of the three-axis rotation stand by 722 I/O card in the semi-physical simulation system of UAV in order to recur the pose angle of system. The three-axis angle speed and pose angle output are sent to the flight control computer by the installation of the sensor built in internal frame.

**Control, guidance and navigation system.** The system of control, guidance and navigation is composed of flight control computer, sensors and actuator.

**Flight Control Computer.** The flight control system of UAV is mainly composed of computer numerical control system and servo control and driving system. The flight control computer is composed of PC-104 general-purpose computer, varieties of PC-104 module, analog signal conditioning circuit and servo control controller. PC-104 modules include D/A, A/D input and output interface board and the SIO serial digital interface board. The rudder machine controller contains the simulation electric rudder servo controller ruled by PID, PWM and the engine analog signals circuitry. All the flight control computer joint by the bus cable and sensors through executive machine [3].

**Actuator.** The flight control actuator of semi-physical simulation system of UAV adopted three electronic rudder machines which contained live digital position feedback devices. It is derived by rudder in order to manipulation and control the UAV [4].

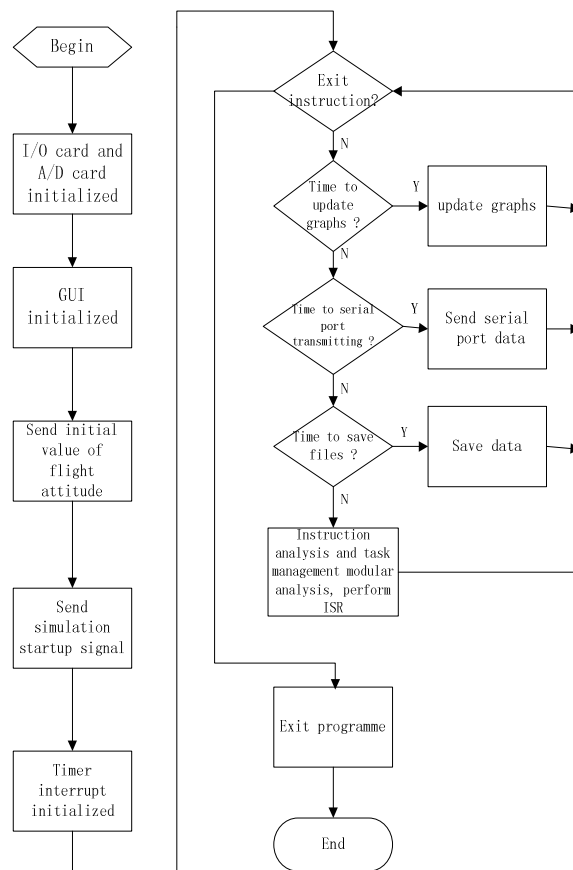


Figure2. The main program flow chart

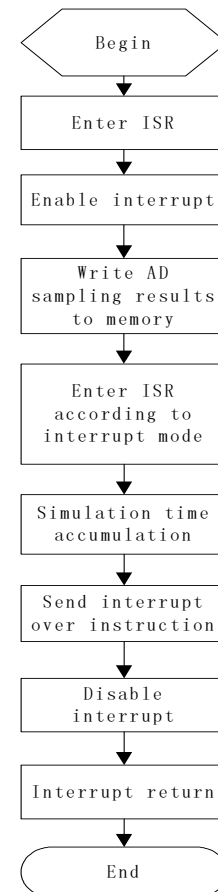


Figure 3. The interrupt program flow chart

**Sensor.** The sensor is the fiber optic gyroscope VG600 which installed in the inner-frame of three-axis flight simulation rotation stand. The VG600 is used to output three-axis fiber optic gyroscope angular speed and pose angle. Solution out of the data packet send to flight control computer in the form of pass[5].

### Software design of semi-physical simulation system

**Software design of flight control computer.** In order to meet the needs of semi-physical simulation system, flight control computer PC-104 industrial control computer operates Windows 2000 system and use Visual C++ 6. 0 as the development tools. The software design of flight control computer includes main program and the timer interrupt program. The flow chart is shown in Figure 2 and Figure 3.

**The software design of simulation computer and monitoring and control computer.** The simulation computer mainly calculates the dynamics models of UAV such as weight, speed, altitude and pose of aircraft. It gives the outputs to three-axis flight simulation rotation stand per 20ms. The simulation computer sends instructions to the flight control computer at the same time, displays and saves the pose, altitude, speed of aircraft and engine status, lines of flight and so on. The display programming of graphic all achieved in Visual C++ 6. 0.

### The results simulation of semi-physical simulation system

The semi-physical simulation test through foundation of semi-physical simulation system proved the correctness of capability and control rule of UAV flight control system, and proved the feasibility and stability of flight control computer software.

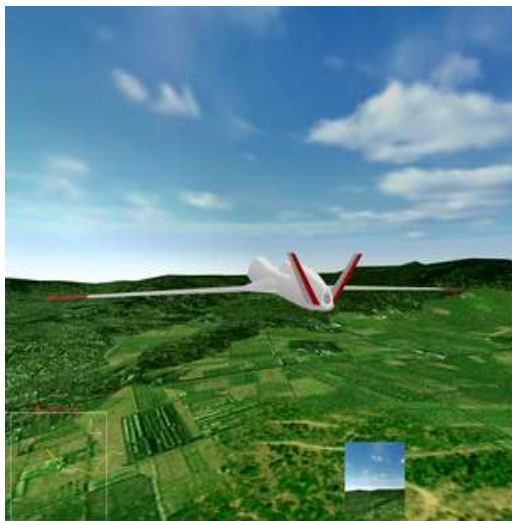


Figure4. Flying simulation result

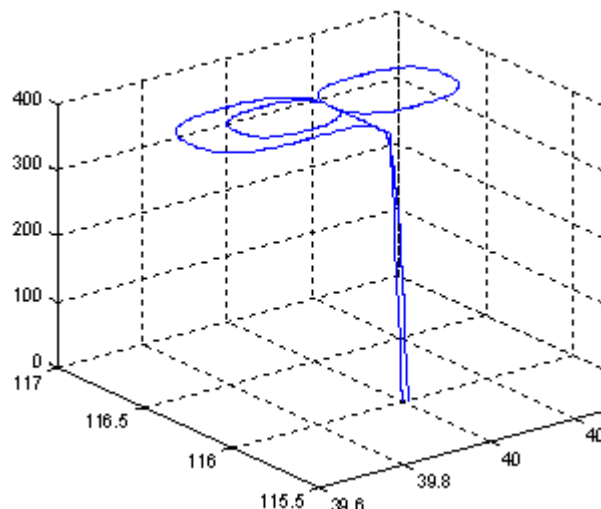


Figure5. Flying path simulation result

The simulation result is shown in Figure 4 and figure 5. The results are anatomized with expectant flight and show that it is stable and has high degree of confidence.

## Conclusion

The paper discussed the semi-physical simulation system of UAV. The semi-physical simulation system can realistically simulate the flight control system operating environment with high confidence and reliability of the simulation. It has qualities evaluation with the research of progress, evaluate the flight character of UAV and save the costs of research. And it can be used in UAV training. In future work, we can amend the mathematic model, control rules and parameter in order to simulate the other UAV.

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