The Study of Integrated Fire/Flight/Propulsion Control (IFFPC) System And Design of Digital Simulation/Design Platform

S.J. Song, Y.Z. Zhang, J.H. Deng
(College of Aeronautics, Northwestern Polytechnical University, Xi'an 710072, China)

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Abstract

A theoretical Integrated Fire /Flight /Propulsion Control (IFFPC) schema and the control law of its subsystem were designed. A hi-fidelity digital simulation/design platform was designed and developed. The simulation result indicated that the level of integration and automatization could be greatly improved through integration of systems; the simulation /design platform achieved the requirement.

1 Introduction

It is one of typical characters that new generation aircraft has integrated fire/flight/propulsion control (IFFPC) system. What is called IFFPC is that integration of fire control flight control and propulsion control make efficient coupling and information sharing between different systems and improve the overall mission capacity of aircraft. We believe that the direction of control system development is integration, automatization and intelligentization. The future attacking system will be a high performance uninhabited weapon platform which can perform full automated attack with high mission efficiency. The flight control and propulsion system will become a single smart aircraft movement control system which incorporate all kind of control capability of aircraft and was highly integrated with command, control, sensor, navigation and attacking system. The value of IFFPC is appearances: it improve the effect of flight envelop; it increase the level of combat aircraft capacity of auto-flight and auto-attack; it also reduce the burden of pilot and increase the survivability and the combat effectiveness of aircraft.

The system integrated was first studied by U.S. in 1970s and were employed in the 3rd, 4th generation aircraft nowadays, such as F-15, F-16, F-22 aircraft[1]. In 1980s U.S studied the AFTI/F-16 program[2]. This program are to develop, to integrate and to flight validate advanced fighter technologies that will enhance the combat effectiveness and survivability of the future fighter aircraft. The approach follow in the two major phases, the first phase is the Digital Flight Control System (DFCS), the other phase is Automated Maneuvering Attack System (AMAS). From 90s U.S. And Russia begin the study on the IFPCS with thrust vector, such as F-15 STOL/MTD（Short Takeoff and Landing / Maneuvering Technology Demonstrator）、F-16 MATV (Multi-Axis Thrust Vectoring)，F/A-18 HATP (High Angle of Attack Technology Program)/ X-31 EFM (Enhanced Fighter Maneuverability) and Su-27 technology of thrust vector test program[1~4,7]. Now the direction of integrated system is integrated vehicle management system (IVMS). IVMS include IFFPC, Environmental control system, aircraft healthy monitor, and fuel system, electronic and power control system. IVMS will enhance aircraft performance and lower the design and repaired cost of aircraft. Chinese research on control integration started in 1990s and mostly limited to theory and digital simulation research.

By this idea this paper focus research on how to realize auto-flight and auto-attack through the integration of flight control, fire control and propulsion control system, a satisfied result would be feasible system integration schemas that could improve the mission performance and enhance the aircraft combat automation.

2 Theory of IFFPCS

2.1 IFPCS[5,6,7]

The IFPCS module is illustrated in figure 1. The mission management unit provide the data to built the track. The track management unit include track built and track follow, can generate the track real-time. The anticipate control input is computed through referent track and actual stat. The IFPCS accept the expectation acceleration and angular acceleration. Last the control allocation computer the input of control surface and thrust vector. Engine control part regular the engine parameter and the throttle of engine base on the demand of different fly stat.

This system employed a Dynamic Inversion based control law[5]. The control law ensures the aircraft with thrust vector have good performance in the area of current angle and high attack angle. The method of minimum control energy used to allocate control effectiveness. This system maximized used of the available control power while meeting stability margins. The engine was controlled by throttle, which was from the IFPCS.

2.2 IFFPC[8]

Using the concept of attack automation

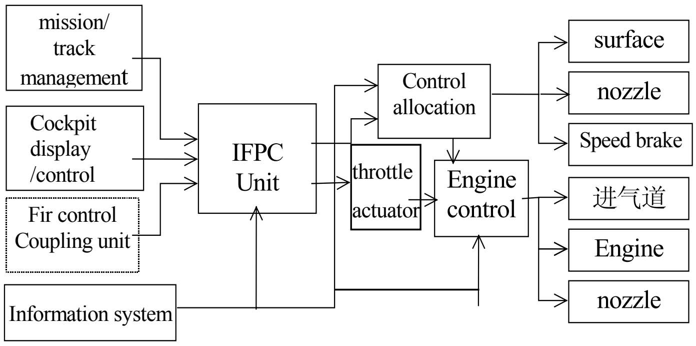


Fig.1 IFPC Module

through the fire control system coupling with the integrated flight/propulsion control (IFPC) system, a theoretical IFFPC schema was designed. The fire control connects with the IFPC through the coupling unit of auto-attack. Receiving output of fire control the coupling unit of auto-attack the input signal of IFPC was formed. The IFPC adjust the control surface and engine, then flight state was changed and errors of aim were reduced. The override controller provide automatic/ semi-automatic/ manual control mode for aircraft. The IFFPC principle block figure is expressed as Fig.2.(*next page*)

The IFFPCS is main system to perform the combat mission. The function includes Target Detection, Target Identification, Target Following, Generate Fir Command and Attack Target. The IFFPCS can detect the target, compute the attack parameter and generate the attack track. In the process of attack the IFFPCS provide the maneuver elusion. The egress maneuver quickly returns the aircraft to the preselected egress track and increased the survivability of the aircraft.

In the process of auto-flight, the Mission/Tactics Management provide reference track such as optimization climb track, terrain following/terrain avoidance (TF/TA). Then the coupling

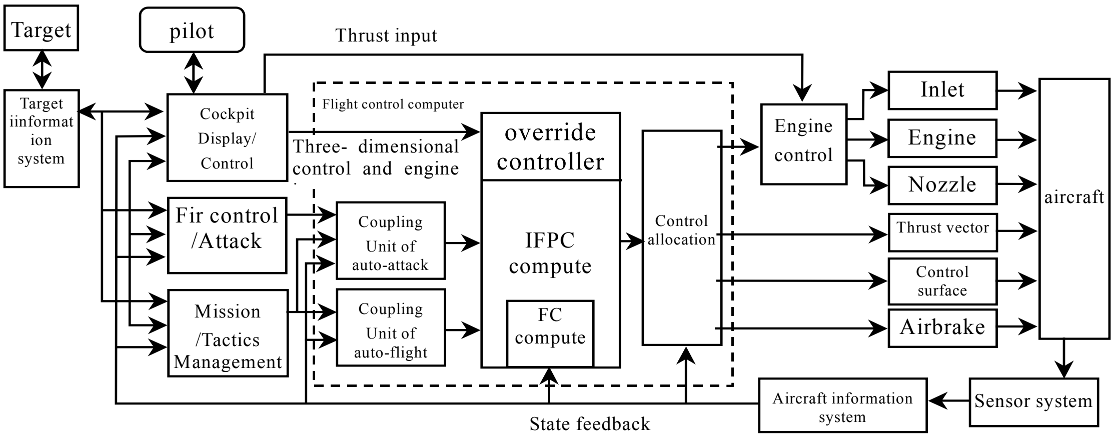


Fig.2 the principle block figure of IFFPC

unit computes the expectative input. The control allocation allots the input to the control surface, thrust vector and thrust. In the process of auto-attack fire control system estimate the movement of aim and bring out attack command. Through the coupling unit the attack command forms the input of IFPC, and control the aircraft complete the attack mission. During the system integration, several key problems were figured out, such as spatial trajectory following, Non-Wing Level (NWL) auto-attack, attack maneuver control.

Through IFFPCS the current combat aircraft can have the capacity of auto-flight and auto-attack, such as TF/TA, AMAS and NWL, so that the attacker's efficiency and survivability, as well as it's overall mission capacity, can be greatly improved.

3 Digital Simulation/Design Platform

Using VC to develop the control algorithm of this platform and OpenGL is used under environment VC to develop this platform for vision demo. Using the DirectX to develop the sound and I/O interface of the platform. The software use the open architecture, a module the simplest form of the software defines s single process. The interface between each module adopts the standard software interface. Every module was encapsulated independently. The main code was written according to the standard C++ criterion.

This platform has the function list as: Controller Design; Controller Test; Controller Measure; Simulation of Auto-Attack, Auto-Flight, IFPC, IFFPC; Vision Demonstration of IFFPC; The test and evaluation of IFFPCS.

The input form of platform is mouse, stick or keyboard. The HUD displays the parameter of velocity, altitude, direction, angle of attack and angle of sideslip. The vision demo display the location and attitude of aircraft. Part of initial input interfaces shown in Fig 3. Vision demo figures were shown in Fig.4

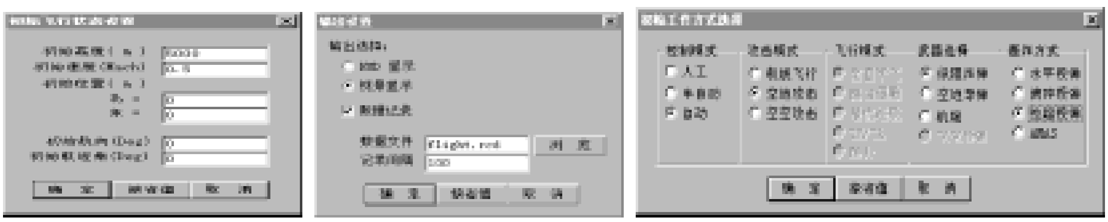


Fig3 input interface of platforms

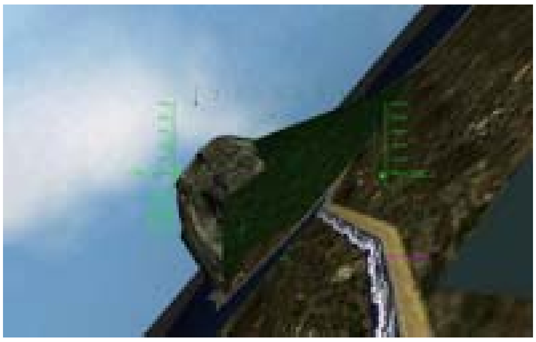
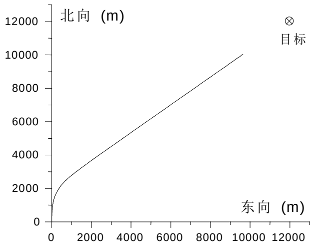


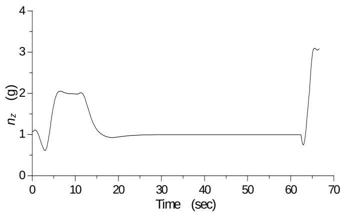
Fig.4 Simulation figure of cockpit vision

4 Simulation Example

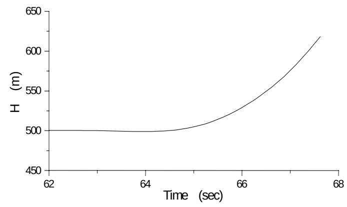
To illustrate the function of IFFPCS. The following cases are simulated to demonstrate the function of IFFPCS. The pull-up bomb process divides two phases. One is aim to the direction of pull-up bomb; the other is steering the aircraft to the weapon-release point and release weapon. The initial target locates 12000m north and 12000m east to aircraft. The aircraft initial speed is 0.6M; initial height is 500m.The direction of flight point to north. Location wind speed is 10m/s. Fig 5 show part of simulation results of pull-up bomb.



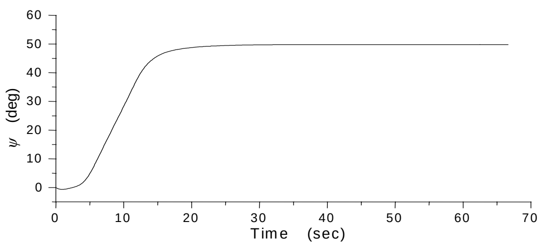
a) pull-up bomb plane track



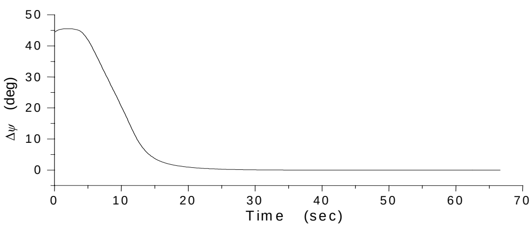
b) over loading



c) height curve



d) Angle of course



e) Errors of aim

Fig.5 Plot of pull-up bomb

Simulation results show the errors of aim less than 1 milli-radian. The precision of auto-attack enhance greatly. The IFFPCS control the aircraft effectively. The system can perform automatic attack very well and increase attack efficiency and attacker's survivability.

5 Conclusion

Based on above studies, we came up with following conclusion:

1). The level of integration and automatization can be greatly improved through the integration of systems, with this improvement aircraft's efficiency and survivability was greatly improved;

2. The digital simulation/design platform satisfies the requirement of design.

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