10.18686/frim.v2i6.4668

The UAV Autonomous Control System from the Perspective of System Engineering

Ning Xiang

Xihua University, Chengdu, Sichuan 610039

Abstract: In order to improve the performance and reliability of UAV autonomous control system, this paper deeply discusses the design method and optimization strategy of UAV autonomous control system from the perspective of system engineering. Article puts forward on the basis of demand analysis, through the system architecture design and integration of functional goals, and on the basis of performance, reliability, security and scalability of comprehensive optimization, aims to build an efficient, stable, safe and good scalability UAV autonomous control system, lay the foundation for the further development of drone technology and application.

Keywords: System engineering; UAV; Autonomous control system

Introduction

With the rapid development of artificial intelligence and automation technology, the uav autonomous control system is facing unprecedented opportunities and challenges. This study focuses on the comprehensive analysis and optimization of the UAV autonomous control system from the perspective of systems engineering, aiming to improve the overall performance, reliability and adaptability of the system. Through systematic application and optimization strategies, this study not only helps to promote the progress of UAV technology, but also provides a valuable reference for solving the common problems in the design of complex systems, which is of great significance to promote the wide application of UAV in various fields.

1. Application of systems engineering method in the design of UAV autonomous control system

1.1 Requirements analysis

In the design process of UAV autonomous control system, demand analysis plays a vital role and lays the foundation for the development of the whole system. Functional requirements define the core capabilities that the system should have, including key functions such as autonomous navigation, task planning and environment awareness, which directly affect the operation efficiency of the system. The performance requirements focus on the operation indicators of the system, such as control accuracy, response speed and endurance ability, which have a decisive impact on the actual application effect of the system. Security requirements focus on risk prevention and control in the process of system operation, involving fault detection, emergency disposal, data security and other aspects, to ensure that the system can operate stably and reliably in a complex environment. Reliability requirements focus on the long-term stability and anti-interference ability of the system, including hardware durability, software robustness, and environmental adaptability, which is crucial to improve the practicality and credibility of the system. Through comprehensive and in-depth demand analysis, the design team can accurately grasp the user expectations, and provide clear goals and direction for the subsequent system design and development[1].

1.2 System architecture design

System architecture design is the core link in the development process of UAV autonomous control system, which directly affects the overall performance and scalability of the system. Hardware architecture design involves processor selection, sensor configuration, communication module integration and other aspects, which needs to seek the best balance between computing power, energy consumption efficiency and weight constraints. The software architecture design focuses on the functional module division, data flow management and algorithm implementation of the system, and adopts the modular and hierarchical design principles to improve the maintainability and scalability of the system. As a bridge between hardware and software, interface design should consider not only account the data interaction between internal subsystems, but also the communication protocol with external devices to ensure good interoperability of the system. Through careful system architecture design, the system complexity can be effectively reduced, the development efficiency can be improved, and a solid foundation for the long-term evolution of UAV autonomous control system.

1.3 System integration

System integration is the key stage in the development of UAV autonomous control system, which directly determines whether each part of the system can play a coordinated function. In the process of subsystem integration, it is necessary to focus on the interface matching and data interaction between the functional modules to ensure the seamless coordination of navigation, control and communication subsystems. The integration of hardware and software requires the verification of software functions on the actual hardware platform, and the necessary optimization adjustments to give full play to the hardware performance. In the integration process, the progressive integration strategy is adopted to gradually improve the stability and reliability of the system through multiple levels of verification, such as unit test, interface test and system test. The success of system integration is not only reflected in the physical connection of each part, but also, more importantly, the realization of functional collaboration and overall optimization of performance, and finally build a highly integrated and superior UAV autonomous control system.

2. Optimization of UAV autonomous control system from the perspective of system engineering

2.1 Performance optimization

In the optimization process of the uav autonomous control system, the performance optimization occupies the core position, which directly affects the overall efficiency and competitiveness of the system. Computational efficiency optimization focuses on algorithm optimization and hardware acceleration, and significantly improves the real-time response capability of the system through parallel computing and distributed processing technologies. Energy efficiency optimization is committed to extending the endurance time of drones, involving power system optimization, the application of energy recovery technology, and the formulation of intelligent power management strategies. The control accuracy optimization aims to improve the handling flexibility and task execution accuracy of the UAV, including the improvement of the sensor fusion algorithm, the fine adjustment of the control model, and the introduction of the adaptive control strategy. The optimization of these three aspects is interrelated and promotes each other, jointly building an efficient, lasting and accurate autonomous control system. Through systematic performance optimization, not only can improve the adaptability of UAV in complex environments, but also can lay the foundation for it to play a role in a wider range of application scenarios, and promote the development of UAV technology to a higher level.

2.2 Reliability optimization

Reliability optimization is the key to ensure the long-term and stable operation of the uav autonomous control system, which has a significant impact on the practical value and safety of the system. As the cornerstone of reliability optimization, fault-tolerant design enables the system to maintain core functions when some components fail by introducing diversity redundancy and dynamic reconstruction technologies. Redundancy design builds multiple guarantee mechanisms from the two levels of hardware and software, such as the backup of key sensors and the multi-mode switching of control algorithms, to effectively reduce the risk of single point of failure. The introduction of fault diagnosis and self-healing mechanism enables the system to have the ability of self-monitoring and problem repair. Through real-time data analysis and intelligent decision-making, potential faults can be identified in time and corresponding remedial measures should be taken. This not only improves the anti-interference ability and environmental adaptability of the system, but also provides a strong guarantee for the reliable operation of the uav under extreme conditions. Through system-level reliability optimization, the UAV autonomous control system can maintain stable performance in complex and changeable environments, opening up new possibilities for its application in mission-critical and high-risk scenarios.

2.3 Safety optimization

Safety optimization plays a crucial role in the design of uav autonomous control system, which is directly related to the credibility and practical application value of the system. Network security optimization focuses on protecting the system from external attacks and data leakage, involving encrypted communication, identity authentication, intrusion detection and other aspects, to ensure the integrity and confidentiality of control instructions and sensing data. The optimization of collision avoidance technology aims to improve the environmental perception ability and path planning intelligence of uav, and greatly reduce the risk of aerial collision by means of multi-sensor fusion, real-time obstacle detection and dynamic path weight planning. The improvement of the emergency disposal mechanism provides a strong guarantee for the system to respond to emergencies, including autonomous return, forced landing, emergency obstacle avoidance and other functions, effectively reducing the safety accidents caused by system faults or environmental changes. Through all-round safety optimization, the uav autonomous control system can ensure its own safety at the same time, maximize the safety of the surrounding environment and personnel, and promote the development of uav technology to a more reliable and responsible direction[2].

2.4 Scalability optimization

Scalability optimization is a key factor to ensure the sustainable development and adaptation of the UAV autonomous control system to future needs, and has a profound impact on the long-term value and competitiveness of the system. The modular design, as the core strategy of scalability optimization, greatly improves the flexibility and maintainability of the system by dividing the system functions into independent but collaborative modules. This design approach makes the system possible to easily add new features or upgrade existing modules without requiring major changes to the overall architecture. The adoption of standardized interfaces further enhances the interoperability of the system, facilitates integration with hardware and software from different vendors, and leaves room for future technology upgrades. The improvement of software reformability gives the system the ability to dynamically adapt to new requirements. Through parametric design, plug-in architecture and other technologies, the system can adjust its functions according to task requirements or environmental changes during operation. Through system-level scalability optimization, the uav autonomous control system can maintain advanced technology, quickly respond to changes in market demand, and lay a solid foundation for uav to play a role in a wider and diversified application scenarios.

3. Conclusion

In conclusion, this paper comprehensively analyzes the design and optimization of UAV autonomous control system from the perspective of system engineering, covering the whole process from requirements analysis to system optimization. By adopting systematic methods and strategies, the performance, reliability, safety and scalability of the UAV autonomous control system can be effectively improved. In the future, with the continuous emergence of new technologies and the increasing diversification of application requirements, the optimization of UAV autonomous control system will face more challenges. Deepening interdisciplinary research and strengthening industry-university-research cooperation will be the key direction to promote sustained innovation and development in this field.

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