Analysis, Design and Application of Micro Multi Rotor UAV Teaching and Training System

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Abstract. With the rapid change of UAV technology, micro multi rotor UAV models are constantly updated and iterated, and the methods and means of flight training are also upgraded and improved. The number of tasks for training micro multi rotor UAV operators is increasing, and the training standards are constantly improving. Under the new situation and new requirements, how to use information technology to reasonably allocate teaching resources and strengthen UAV teaching management, which can effectively reflect the teaching level of teachers and the learning effect of students, has become the most urgent problem. Combined with the current training status of micro multi rotor UAV, this paper puts forward the necessity of analyzing and constructing the construction of micro multi rotor UAV teaching and training system, gives the analysis and design scheme of the system, and specifically expounds the overall design, feasibility analysis, functional design, system quality attribute requirements and scalability analysis system quality attribute requirements of the system. The system is applied to the learning and training of two training courses. Through the analysis and comparison of the assessment results of the students, it is obvious that the application of the system can effectively improve the overall operation level of the students and shorten the training cycle.

Keywords: UAV teaching · System analysis and design · System application · Improve the operation level

1 Current Training Status of Micro Multi Rotor UAV

With the increasing application of micro multi rotor UAV in various industries, the demand for the number and skills of micro-UAV operators is also increasing. In recent years, training institutions for micro multi rotor UAV training have sprung up, the number of training tasks is increasing, and the training requirements are also increasing. How to use information technology to reasonably allocate teaching resources, strengthen the teaching and training ability of micro multi rotor UAV, and effectively improve the

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teaching level of coaches and the learning effect of students has become the most urgent problem [2].

First, the training system is not standardized and unified. As the existing micro multi rotor UAVs come from different manufacturers, there are differences in equipment models and performance indicators of the micro-UAVs purchased and used by training institutions, which leads to the inconsistency of training methods in the same training subject in different training institutions, the poor unity of actual operation of teaching and training, and the inconsistent improvement level of students' skills.

Second, the training ground is not fully guaranteed. A complete UAV training process consists of theoretical learning room, computer simulation flight room, indoor hovering flight training hall, outdoor multi subject flight training field and 100-m altitude airspace [5]. The settings and standards of each field are also very different due to different training contents and standards. Various training institutions are incomplete in site settings, and some need to combine site training.

Third, the level of flying coaches is uneven. At present, most of the flight coaches in various training institutions are held by personnel holding AOPA over the horizon driver's license, and some are held by personnel holding AOPA instructor's driver's license [1]. Each flight instructor's own level and flight experience are different, and the teaching methods and means are also inconsistent. Although the framework structure of the overall training is unified, the trainees have to adapt to the training methods of each coach during the training, which may lead to the slow improvement of personal summary.

2 Overall System Design

In order to achieve good training effect and standardize the unity of training and standards of training institutions, this system is analyzed and designed. The full name of this system is "micro multi rotor UAV teaching and training system". It is a LAN UAV teaching and training system developed for students engaged in micro multi rotor UAV Control in the future. It can share data, improve training efficiency, clarify training process, standardize training standards, and closely combine coach, teaching, training, courses, students and evaluation, Integrate the theoretical learning and testing of micro multi rotor UAV, simulated flight training of micro multi rotor UAV, indoor hovering flight training and outdoor multi subject flight training, so as to form an organic combination of online and offline teaching and training mode. At the same time, it provides the background management and data export function of micro multi rotor UAV training system, and provides an open port for later maintenance, upgrading and expansion [3] (Fig. 1).

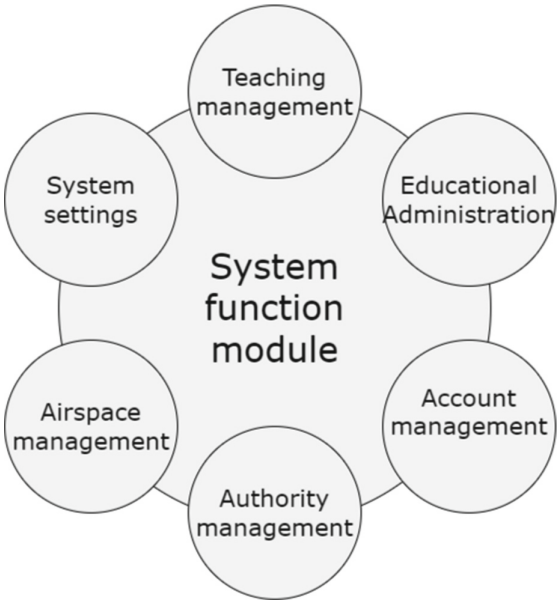

Fig. 1. Overall system block diagram

3 System Function Design

3.1 System Function

3.1.1 Home Page Display

On the homepage of the software interface, you can see the two-dimensional orthophoto map of the field of practical training, the current parameter indicators of the micro multi rotor UAV for practical training, and the UAV number list, in which you can display whether it is online or not. In principle, after the UAV information is registered and imported into the system, if the UAV is powered on, the corresponding number of the UAV should be online.

3.1.2 Practical Operation Record

The actual flight data of the trainees every time shall be recorded and saved in the background of the system. After the trainees use the UAV for actual operation training according to the actual operation process, the actual operation record column can display the results and flight dynamics of the trainees in the current training. The interface can display the training history of each actual operation subject. Each record can display the flight instructor, UAV number, current training subject, score loss point and AI analysis of student operation data.

3.1.3 Practical Training Subjects

According to the requirements of teaching and training standards, the system provides general teaching subjects for micro multi rotor UAV. These subjects can be added to the course as the content of course teaching. Different subject types correspond to different courses. We can arrange courses by any combination of subjects in the course, or update subjects and adjust courses through the background [4].

3.1.4 Course Selection and Completion Progress

Students can view the chapter information of the course and study by clicking on the course details, and can view the learning progress of the course by clicking on the progress.

3.1.5 Coach Management

After the system administrator adds a coach in the coach management office, the student side can select a coach in the coach management office. The coach can select or directly select students through the coach side and schedule classes.

3.1.6 Student Management

Add student: A student can select multiple courses and join multiple courses at the same time. The subjects corresponding to the courses should be added multiple times to correspond the subjects to the courses. Multiple course selection records of the student will be displayed in the system.

Student QR code: After adding a student and selecting a course, the system will generate a QR code for the student. The QR code is continuously recorded and updated as the progress of students' learning and training changes. In the background of the system, you can export the two-dimensional code of students in batch by selecting multiple from the student list, or you can click the preview button of a student's two-dimensional code column to view the two-dimensional code. The two-dimensional code can be downloaded and printed.

Students' learning: The system background, coach end and student end can view the student's learning situation and AI analysis data of learning and training.

3.1.7 Authority Management

Authority management is divided into user authority and administrator authority. User rights: coach and student roles in the system. The coach is responsible for leading the students to practice UAV training flight; Students are responsible for theoretical learning and simulation training using app or computer.

Administrator authority: system administrator user, responsible for managing system resources, system configuration and viewing the overall situation of the system. System administrators can be divided into different administrators according to different permissions in the system. The system administrator authority design is designed according to RBAC model, that is, role, authority and user model. First assign the authority to the

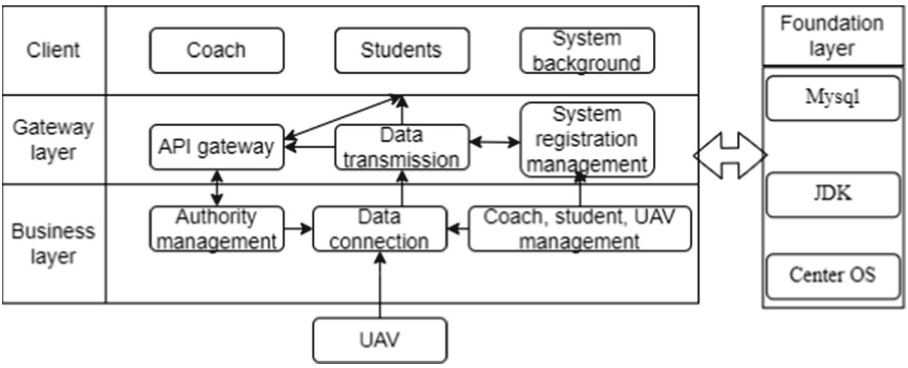

Fig. 2. System architecture design

role, and then assign the role to the user. In this way, the authorization will be more flexible and convenient (Fig. 2).

3.1.8 Flight Detection

Edit the test item of UAV model: Detailed preflight detection shall be carried out for each UAV with flight. According to the distinction of UAV models, the detection of wind resistance and actual operation temperature range under weather conditions shall be edited and uploaded; Edit and upload the detection of the intervisibility degree of the flight site environment and the magnetic field environment; Edit and upload the qualification of the flying instructor and the learning level test of the practical operation students; Edit and upload the remote control data connection, rocker paddle position and battery power supply detection.

Test record: You can check the flight inspection records of micro multi rotor UAV before flight by comparing the above detection items.

3.2 Curriculum System Design

The curriculum system is divided into three parts: major, course and subject.

Specialty: the training of micro multi rotor UAV instructor, Captain and pilot is distinguished here, and the corresponding course collection is set for different specialties.

Courses: each course is composed of multiple learning subjects. Subjects between courses can be used alternately to rationalize resources.

The course includes a variety of courses, common questions and learning resources, such as video analysis.

In order to make the system more scalable, the curriculum system is designed as a tree directory. Each node of the directory can be associated with any learning resources, including videos, documents and so on (Figs. 3, 4, and 5).

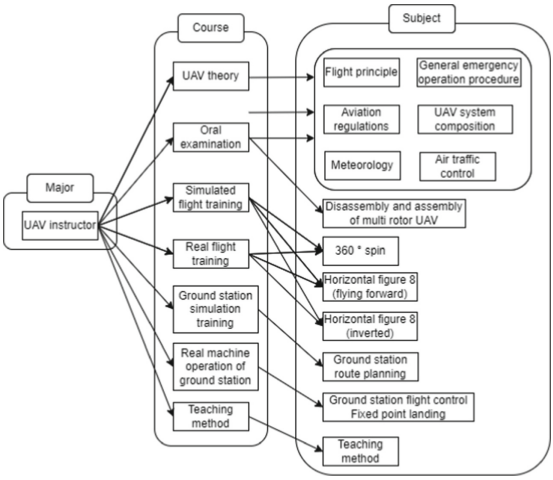

Fig. 3. UAV instructor training course system diagram

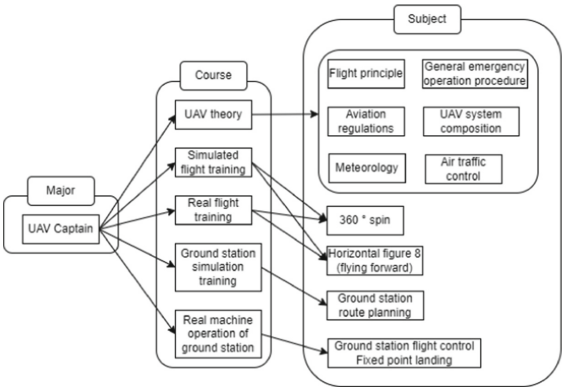

Fig. 4. UAV captain training course system diagram

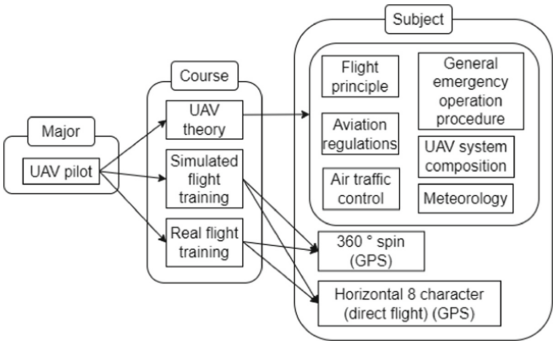

Fig. 5. UAV driver training course system diagram

4 System Quality Attribute Requirements

4.1 Robustness

The system can catch exceptions in each step of operation, and the exception records can be automatically transmitted to the console to form a log file. The maintenance personnel can locate and solve the problems existing in the operation of the system through the log file.

4.2 Performance Design

The performance design of the system mainly includes:

Cache mechanism: the cache mechanism is introduced during task scheduling to take out the data of the task table and put it into the cache, which improves the reading performance;

Data processing: if the data taken from the intermediate library needs processing, it needs to be put into the cache during processing;

The time of applying the support layer shall be controlled within 5 s.

4.3 Ease of Use Design

The system deployment is simple, and the installation manual and configuration manual are provided. After starting the system, you can judge whether the system is running normally through simple instructions, and there is detailed system startup log information. Provide the business system call interface description document, describe the parameter call method of each interface in detail, and provide examples for some typical scenarios.

4.4 Continuous Availability Design

The modular design method is adopted. Each module exposes the service through the interface and provides it to other modules to ensure continuous availability.

4.5 Scalable Design

The system can adjust the size of the request service parameters according to the actual hardware environment to adjust the query service capability.

4.6 Interoperability Design

The application support layer adopts modular design, and each module is exposed in the form of interface and provided to other business systems for calling; In addition, it is convenient to call business system functions by configuring interconnection.

4.7 Reliability Design

The system can operate continuously for 3 * 24 h.

4.8 Comprehensible Design

The words appearing in the help documents related to the system do not use computer proper nouns, but use well-known nouns of UAV training institutions, and provide relevant explanations.

4.9 Scalable Design

System scalability includes: the system improves system scalability by flexibly adapting to the changes of data center dictionary. Instead of using static coding (enumeration) to limit the range of parameters, the basic type values representing object type, protocol type and data source type are directly passed in. The dictionary value of the data center is obtained inside the program to verify whether the parameters passed in are legal. When the data center adds object type, protocol type and data source type, there is no need to modify the code to improve the scalability of the system.

4.10 System Maintainability Design

First, for ordinary operation and maintenance personnel, the system uses Log back to record the input parameters, output parameters, request time and the number of returned results of each request in detail.

Second, for research and development personnel, the system logs through Log back to record in detail the input parameters of sub query in each request, the request time of each stage, the number of returned results, etc.

Third, for business developers, the system requests to return the status code. Business developers can judge the response status of the request through the status code and quickly locate the status information through the status code.

Fourth, periodically synchronize cached data.

4.11 System Testability Design

The system provides self-test function and swagger test page, which can directly test the interface on the web page. It is equipped with detailed interface documents, and a total of testers conduct more detailed function and performance tests.

4.12 Portability Design

The application support layer is developed in Java, which has strong displacement.

5 System Generalization Analysis

The micro multi rotor UAV teaching and training system is a stand-alone teaching system. It is used internally by UAV training institutions and can effectively ensure the safety of training data of training institutions. The system administrator does not give the functions of data entry, query, modification and clearing the database, and does not provide the functions of Internet network search and upload.

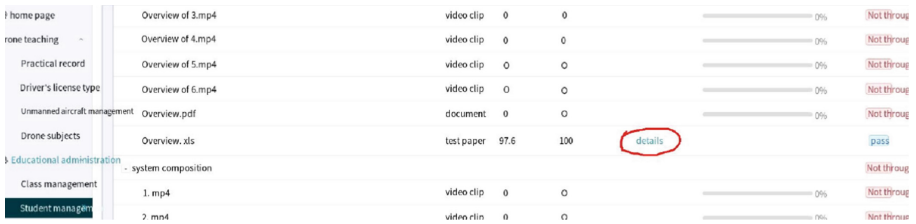

Fig. 6. List of students' learning

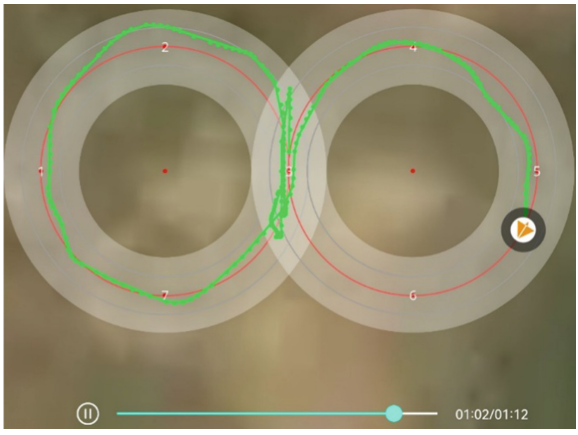

Fig. 7. Real flight trajectory playback of UAV

5.1 Technical Scalability

The system operates in the built LAN environment. The micro multi rotor UAV needs to carry out teaching and training in the area where the LAN signal can be well covered, and can maintain normal data communication with the system, so that the system can correctly evaluate and record the effect of UAV teaching and training. At present, UAV training institutions all over the country have a good level of network construction and can meet the technical requirements.

The hardware equipment required by the system, such as server, PC and network accessories, do not have high requirements for the performance indicators of the above hardware equipment. In terms of software, network operating system and database management system have been widely used in MIS development, and the technology is relatively mature. Typical operating environment: Center OS 8, JDK 8 and MySQL 5.7. At present, the hardware construction level of UAV training institutions around the country is high, and the software used can also ensure its good operation (Fig. 6).

5.2 Operation Scalability

At present, all training institutions have formed a relatively standardized teaching system in UAV teaching and training. While retaining their existing teaching system, the micro

multi rotor UAV teaching and training system can distinguish the existing teaching system into multiple modules and realize modular information management. At present, it has been used in many teaching and training institutions and colleges, and the coaches and students generally respond well (Fig. 7).

6 System Application Analysis

We compare the trainees in 2018, 2019 and 2020. In 2018, we use the traditional methods of coach teaching demonstration, students' learning and training, and memorizing theory after class. In terms of theoretical learning, we mainly distribute paper question bank, students memorize after class, and teach and practice random test; In the real flight, the coach will first conduct teaching demonstration, adopt the method of doing while speaking or doing before speaking, use the training machine for indoor hovering training, use the assessment machine to take it to the outdoor assessment site for fixed subject training, and the coach will correct the problems existing in the flight of the students in the way of third person visual inspection. Figure 8 is the histogram of the learning and training results of the trainees trained in 2018, and Fig. 9 is the histogram of the time when the trainees trained in 2018 passed the examination. Through the chart analysis, we can see that the excellent rate of the trainees in 2018 was 20%, the good rate was 13.3%, the medium rate was 46.7%, the pass rate was 20%, and the overall time spent was 33.2 days.

In 2019 and 2020, two groups of students used the system to carry out supporting teaching and training. In terms of theoretical learning, they adopted the methods of

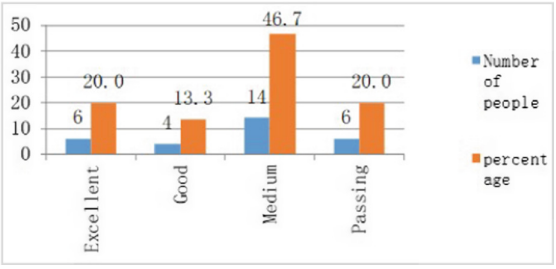

Fig. 8. Statistics of learning and training achievements of trainees trained in 2018

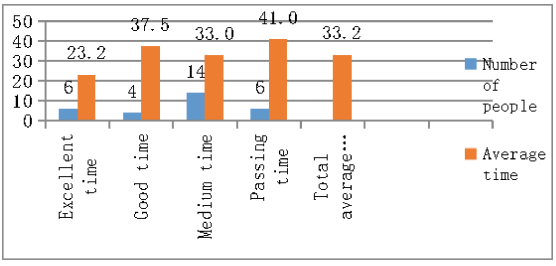

Fig. 9. Time statistics of trainees passing the examination in 2018

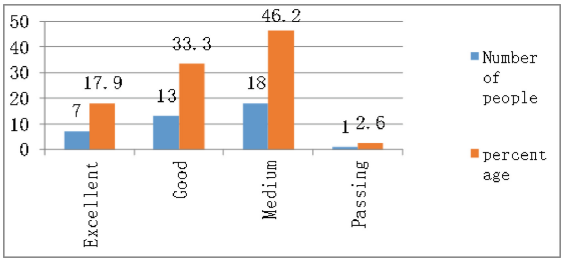

Fig. 10. Statistics of learning and training achievements of trainees trained in 2019

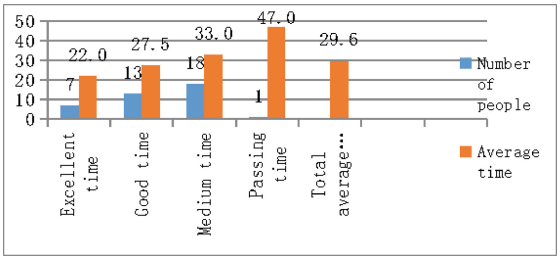

Fig. 11. Time statistics of trainees passing the examination in 2019

online memorization theory, simulated on-line examination, question extraction and solution in the question bank, and repeated practice of wrong questions to consolidate and strengthen theoretical learning. In terms of real flight, first use the courseware to learn the basic action points, watch the video to understand the actual flight state, use the computer software to simulate the flight training management, real flight operation practice, record the flight route, look back and correct the problems existing in the flight process, and the coach can correct the errors and answer the questions in time. Figure 10 is the histogram of the learning and training results of the trainees trained in 2019, and Fig. 11 is the histogram of the time when the trainees trained in 2019 passed the examination. Through the chart analysis, we can see that the excellent rate of the trainees in 2019 was 17.9%, the good rate was 33.3%, the medium rate was 46.2%, the pass rate was 2.6%, and the overall time spent was 29.6 days. Figure 12 is the histogram of the learning and training results of the trainees trained in 2020, and Fig. 13 is the histogram of the time when the trainees trained in 2020 passed the examination. Through the chart analysis, we can see that the excellent rate of the trainees in 2020 was 30%, the good rate was 47.5%, the medium rate was 5%, the pass rate was 17.5%, and the overall time spent was 18.9 days.

By comparing the assessment and learning time of the three sessions of students, it is not difficult to find that the good rate of the students who use the system is significantly improved, the average time to pass the assessment is shorter, and the number of coaches can be reduced, saving teaching resources.

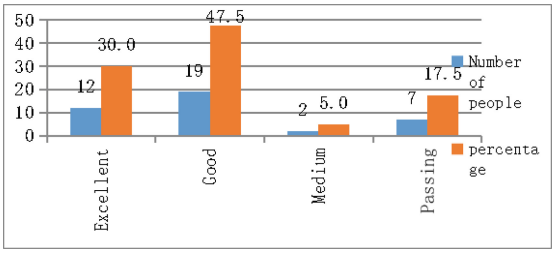

Fig. 12. Statistics of learning and training achievements of trainees trained in 2020

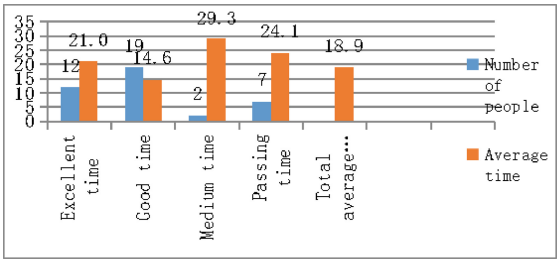

Fig. 13. Time statistics of trainees passing the examination in 2020

7 Concluding Remarks

There are many indicators that affect the teaching and training effect of micro multi rotor UAV. The micro multi rotor UAV teaching and training system can greatly shorten the training time, standardize the consistency of teaching and training standards of different coaches, effectively stimulate the students' enthusiasm for autonomous learning, and better enable the coaches to master the specific steps and existing problems of students learning the control of micro multi rotor UAV, It can make students better understand the specific problems in which step of their own learning and training process, and provide effective technical means and important data reference for the teaching and training of micro multi rotor UAV. It can also conduct self-study of theoretical and simulation training through video viewing and lesson plan learning in case of shortage of coaches, or find and correct the problems existing in practical training through system review. In short, as an emerging industry, UAV training has broad prospects and benefits. We should keep pace with the times, make full use of information means to build and improve the teaching and training mode and cultivate high-quality operators.

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References

1. Chen Yingsong, LI Hongwei. (2022). Research and Practice on the Construction of UAV Application Technology Specialty in Higher Vocational Colleges. J Modern Manufacturing Technology and Equipment. 304 (3), 212–214
2. Huo Xiaoyan, Liu Weijie, Li Wei. (2021).Research on personnel training of UAV practical training. J. China's modern educational equipment. 353 (1), 55–56
3. Jiao Yongkang, Chen Yong, Yu Jinyong. (2018). Design and development of UAV Simulation Training System. J. Computer Measurement & Control. 26 (1), 209–212
4. Shen Bin, Li Tan, Fu Xiaojin. (2016).Research and Practice on new teaching and training means of UAV . J. China New Technologies and Products. (1), 20
5. Xing Na, Li Yongke, Zhang Yuhua, Chu Lina, Wang Wenjuan.(2022)Research on Actual Combat Teaching and Training of UAV Practice Courses. J. China Modern Educational Equipment. 383 (7), 152–154