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Application of Technical Standards and Cascade Control Theory in Undergraduate Program for Unmanned Aerial Vehicle System Engineering Major

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Abstract: In recent years, with the rapid development of unmanned aerial vehicle system industry, there is a huge demand for professionals, and some universities in China offer unmanned aerial vehicle system engineering specialty. In this paper, the application of technical standards and cascade control theory to the undergraduate program of this major is given. This scheme integrates teaching quality supervision system, curriculum system, curriculum content and assessment mechanism. This scheme optimizes the curriculum system and content, establishes an effective assessment mechanism and a strict teaching quality supervision system, and introduces technical standards to replace the examination system of examination scores to ensure the implementation and implementation effect of the talent training scheme.

1. Introduction

Higher education should be more adapted to the needs of economic and social development. Colleges and universities should take meeting the needs of economic development and serving the society as the primary responsibility. Colleges and universities cultivate talents for the society to meet the needs of economic and social development [1]. At present, with the rapid development of unmanned aerial vehicle system industry, China urgently needs comprehensive talents in the field of unmanned aerial vehicle system industry. To this end, our school applied for adding unmanned aerial vehicle system engineering major in 2017, and was approved by the Ministry of Education in 2018. In the same year, undergraduate students were enrolled, aiming at cultivating comprehensive talents

in the design, application, airworthiness and management of unmanned aerial vehicle systems and laws and regulations. Undergraduate students majoring in unmanned aerial vehicle system engineering trained by our school can work in research institutes and various enterprises in related industries and fields of unmanned aerial vehicle system.

Unmanned Aerial Vehicle System Engineering is an undergraduate major set up by the Ministry of Education for the record and approval. The major code is 082009T, the degree-granting category is engineering, and the length of study is four years. From 2017 to 2020, the Ministry of Education announced the "Record and Approval Results of Undergraduate Majors in Ordinary Colleges and Universities", which approved 16 ordinary colleges and universities to newly set up unmanned aircraft system engineering majors. By June 30, 2020, there were 3,005 institutions of higher learning in China. At present, the number of ordinary colleges and universities offering unmanned aerial vehicle system engineering specialty accounts for only 0.58% of the total number of colleges and universities in China, and this specialty has become a new major that domestic colleges and universities are scrambling to set up and build. There is no more experience for the construction and personnel training of this major, and these universities are facing pressure and challenges. In this paper, a talent training scheme for unmanned aerial vehicle system engineering is proposed, which integrates technical standards and cascade control theory, and is shared with other engineering majors and schools for reference.

2. The Teaching Quality Supervision System Based on Cascade Control Theory

2.1. The Application of Closed-loop Control in Teaching Quality Supervision

In control theory, the structure of closed-loop cascade control system is shown in Figure 1, and the control system whose system output affects the system input is called closed-loop control system. Its basic principle is to realize the expected state (main parameters) by using the loop of feedback control information and its controller adjustment [2]. The application of closed-loop control in teaching supervision takes bilateral teaching activities as an example. The subject teacher as the controller exerts educational and teaching influence on the object students, and the object students as the main object compare the learning efficiency and effect with the expected goal, and then return to the subject teacher in an effective way. When the subject teacher finds that there is a difference between the actual learning goal and the expected target value of the controlled object students, the subject teacher will send out correction information according to the deviation and degree of the learning goal, that is, eliminate the deviation, eliminate foreign learning interference or improve learning methods. In the talent training scheme of this major, the closed-loop cascade control principle is applied to the teaching quality supervision system, and applied to the construction and evaluation of undergraduate teaching projects to ensure the realization of high-quality talent training objectives.

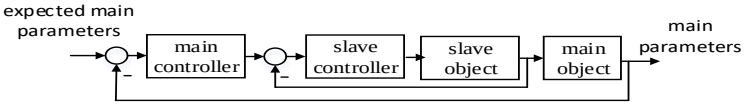

Figure 1: Structure diagram of closed-loop cascade control theory system.

2.2. Cascade Control Theory+feedforward Teaching Quality Supervision and Curriculum System Implementation Plan

At present, the open-loop teaching quality supervision system is usually adopted, as shown in Figure 2. In the process of cultivating students, teaching is carried out in chronological order according to the formulated talent training plan, and basic courses (compulsory courses for general education and compulsory courses for disciplines) are arranged in the first semester to the fourth semester, and professional courses (compulsory courses for majors and elective courses for majors) are arranged in the fifth semester to the seventh semester for teaching and assessment. As can be seen from Figure 2, the assessment leaders of basic courses and specialized courses are basic course teachers and specialized course teachers respectively. First, basic courses are the prerequisite courses and the basic content of specialized courses, and there is a chronological relationship between them. Second, there is a substantial separation between the contents of basic courses and professional courses. Because the teachers of basic courses and specialized courses are not in the same college/department/teaching and research section, such as College Physics in the Faculty of Science, Circuit in the Department of Electrical and Electronic Engineering and Aircraft Integrated Control System in the Department of Aviation Control, the teachers of basic courses and specialized courses are in a state of lack of communication or separation, and they are teaching according to the syllabus formulated by each college, especially the teachers of basic courses and specialized courses who are the leaders of assessment implementation. For students, when learning basic courses, it is not clear about the purpose of the basic courses and whether they can be used in the following semester. At the stage of studying specialized courses, students can remember or forget some of the contents of basic courses, which does not play the role of basic courses in studying specialized courses. In this way, there is a lack of connection between basic courses and specialized courses, which reduces students' learning enthusiasm and purpose and seriously affects students' learning effect. In order to solve these problems, it is not feasible to let the teachers of basic courses complete all the professional courses because they can't master both basic courses and professional courses. On the contrary, it is feasible for basic course teachers to supplement some professional courses and professional course teachers to further deepen the basic course content.

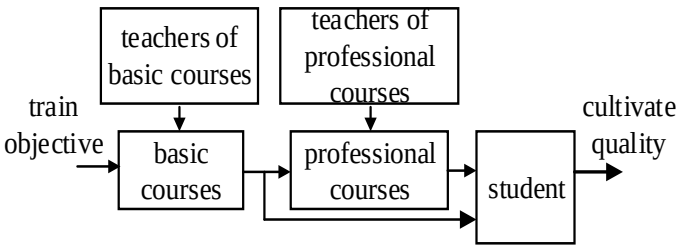

Figure 2: Open-loop teaching quality supervision system.

For this reason, in view of the above phenomena and problems, and UAV is the carrier to solve complex engineering problems, and UAV professionals need close knowledge and skills, a teaching quality supervision and curriculum system scheme based on cascade control theory and feedforward is proposed, as shown in Figure 3. Its main contents include: First, the teaching quality supervision

system of closed-loop cascade control theory is established, and the quality of teaching and training is guaranteed by double feedback evaluation of basic courses and professional courses; Secondly, aiming at the unmanned aerial vehicle system engineering specialty, the curriculum system and practical teaching links for solving complex engineering problems are established; Thirdly, the contents of basic courses and specialized courses are crossed, and the contents used in related specialized courses are given predictively in basic courses to ensure the close connection between the contents of basic courses and specialized courses.

In Figure 3, the objects controlled by the inner and outer loops are all students. Inner-loop control consists of basic courses, slave controllers (teachers of basic courses) and inner-loop assessment, in which the feedback of some professional courses is added. Outer loop control consists of specialized courses, master controller (specialized course teacher) and outer loop assessment. Inner-loop control ensures the teaching quality of basic courses, while outer-loop control ensures the teaching quality of specialized courses. Under the control of inner and outer double loops, the quality of cultivating students is guaranteed and improved.

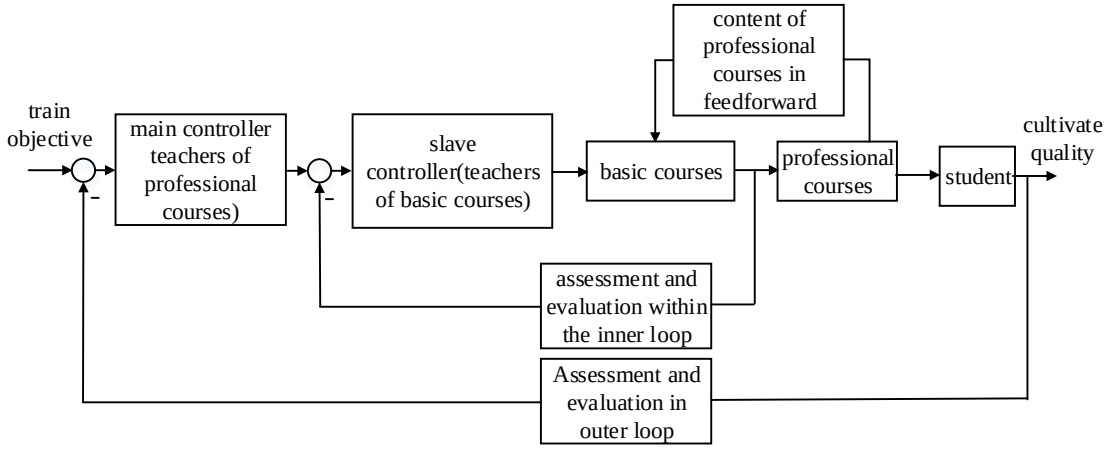

Figure 3: Teaching quality supervision and curriculum system based on cascade control theory and feedforward.

3. Curriculum Optimization and Teaching Content Design Based on Technical Standards

At present, China is vigorously promoting supply-side reform to realize the strategy of strengthening the country by quality from "high-speed growth stage" to "high-quality development stage". In this new era, in order to achieve "high-quality development" of safe, controllable and benign health, the domestic civil UAV industry must establish and improve the standards, testing and certification systems and industrial systems, among which the construction of the standard system is the premise and foundation, and it is also an urgent task. At present, for the civil UAV industry, it is gradually improved according to the five levels of national, industry, local, group and enterprise standards of the national technical standard system. Relevant departments at all levels in the country attach great importance to the construction of the standard system of civil UAV systems. The published standards, mainly formulated by some national ministries, associations and industrial alliances, are mainly local, industrial and alliance standards, with a total of 37 items, including 14

industrial standards, 7 local standards, 12 alliance standards, 2 group standards, 1 CQC standard and 1 enterprise standard. The formulation of these standards has played an important role in regulating and guiding the production of domestic civil UAV enterprises, improving product quality, reducing production costs, standardizing market order, developing domestic and foreign trade, and promoting economic development and social progress [3]. Therefore, in the talent training of colleges and universities, technical standards should be integrated into talent training, so that students can master the content of technical standards and have the awareness of technical standards when they graduate.

3.1. Importance of Cultivate Awareness of Technical Standards

Technical standards refer to any series of technical specifications that provide general design of products or processes. For enterprises, technological innovation and standardization are developing at the same time, and technological innovation realizes scale and industrialization through standardization. When a new standard is established, it can be said that a new technology is recognized by the market and adopted, which usually brings huge economic benefits to enterprises [4]. General Secretary of the Communist Party of China put forward and emphasized the standardization strategy many times [5]. Standards are the technical support for economic activities and social development, and also the basic system for the modernization of national governance system and governance capacity [6]. In recent years, the dispute over standards has become more and more fierce, and standards have become the key factor that determines the life and death of enterprises, and enterprises have changed from product competition to standard dispute. Combining the curriculum setting, teaching content design and corresponding technical standards of engineering majors in colleges and universities, introducing technical standards into talent training in advance, and cultivating students' awareness of technical standardization. In the training of engineering students in colleges and universities, we should also be deeply aware of the huge benefits brought by technical standardization to enterprises. Fully aware of this, there is no reason not to introduce this huge benefit into higher education, on the contrary, it will bring huge dividends to higher education.

3.2. Awareness of UAV Laws and Regulations

In recent years, there have been many incidents in which civil airliners were forced to stop by civil drones, and civil drones have become the "invisible killer" of civil airliners. The frequent occurrence of "black flying" incidents of unmanned aerial vehicles seriously disrupts air traffic control, endangers air traffic safety, may also endanger the safety of people's lives and property, disturb social order, and more seriously, may endanger national security and have serious security risks. The state and local governments have successively issued a series of laws, regulations and notices on the management, specification and application of unmanned aerial vehicles [7]. Therefore, in the process of personnel training, attention should be paid to the study of UAV laws and regulations to manage the legal and compliant application of UAV systems, so as to ensure that the development, production, sales and use of UAV systems are completely on the track of the rule of law.

3.3. Technical Standards into the Teaching Content

We set up courses and design teaching contents around technical standards, and integrate technical standards into curriculum theory teaching, practice teaching and graduation design. The main research contents are as follows. First, the curriculum and teaching content design scheme based on technical standards are given. Second, we study the scheme of assessing students' teaching links based on technical standards, instead of the original method of taking scores as the basis of curriculum assessment. The third is an example of graduation design content and assessment criteria based on technical standards.

4. The Integration of Technical Standards and Cascade Control Theory of Talent Training Program

Based on the above analysis, the talent training scheme integrating technical standards and cascade control theory is shown in Figure 4. This scheme integrates curriculum system, curriculum content design and teaching quality supervision system. The curriculum system includes basic courses and specialized courses, and there is a cascade relationship between them. Course content design includes basic courses and professional content, and there is a cascade+feedforward relationship between them, and the content of relevant technical standards is introduced. In the teaching quality supervision system, the closed-loop cascade control mode of main controller and slave controller is adopted, the inner and outer ring assessment mechanisms are set up, and the assessment content of technical standards is introduced. Therefore, with reference to this plan, a talent training plan is formulated from three aspects: curriculum system, curriculum content and teaching quality supervision system to ensure the quality of talent training in this major.

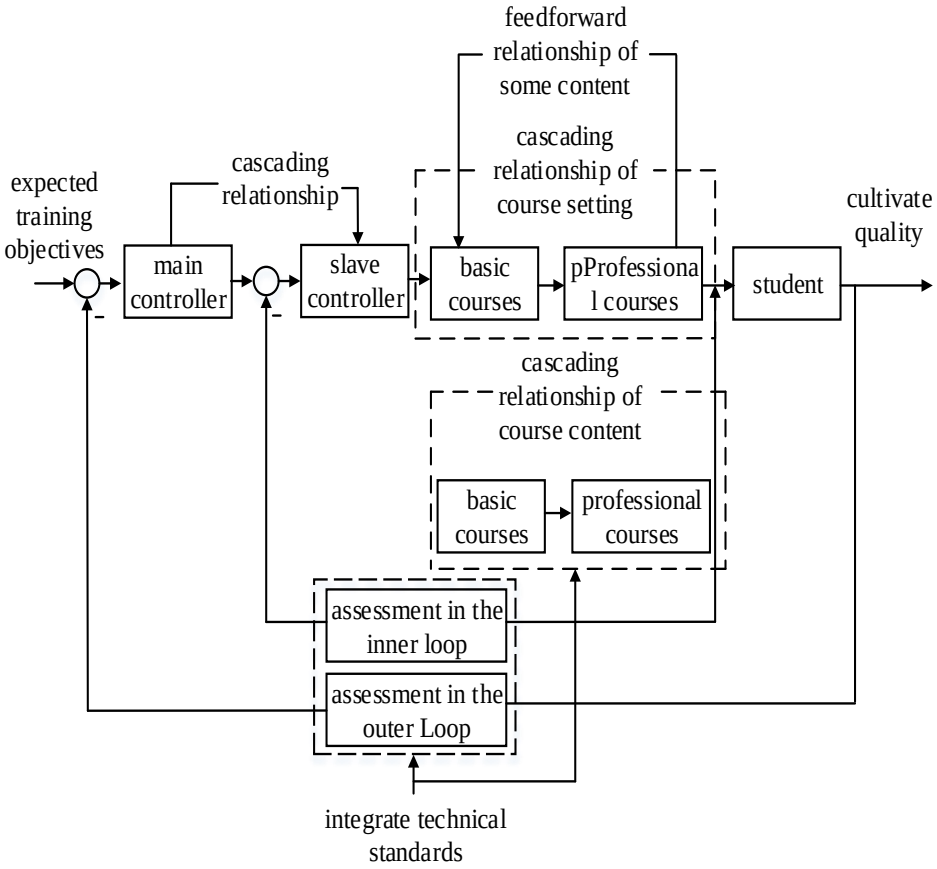

Figure 4: Talent training scheme integrating technical standards and cascade control theory.

4.1. Curriculum System

The curriculum system of this major is shown in Figure 5 and Figure 6. There are five main courses in the curriculum system of this major: general ducation required course, subject‘s required course, major required courses, professional elective courses and practice session, and there is a cascade and feedforward relationship among them. If the main theoretical courses and practice session are arranged from the first semester to the seventh semester, graduation internshipe and graduation design will be arranged in the eighth semester. In order to enable students to meet the necessary ability standards when they graduate, this major has set up three major core curriculum modules: UAV embedded electronic system, UAV automatic control system, UAV machine vision system and Python language development. The course of embedded electronic system for UAV is a course module which focuses on the knowledge and skills of embedded development needed for UAV development, taking into account the traditional embedded single chip microcomputer development course. Its main course contents are single chip microcomputer foundation, sensor acquisition, data processing and filtering, and operating system application. The course of UAV automatic control theory system is a course module around the basic knowledge of UAV system, automatic control theory knowledge, practical skills of automatic control algorithm design, parameter tuning skills and so on, which highlights the characteristics of UAV, attracts students' interest and strengthens and enhances students'

ability to solve complex problems. The course of UAV machine vision system and Python language development is a course module around the knowledge and skills of UAV machine vision development and Python language development, aiming at cultivating the ability of Python language development, I/O processing, image processing based on OpenCV and the application of convolutional neural networks.

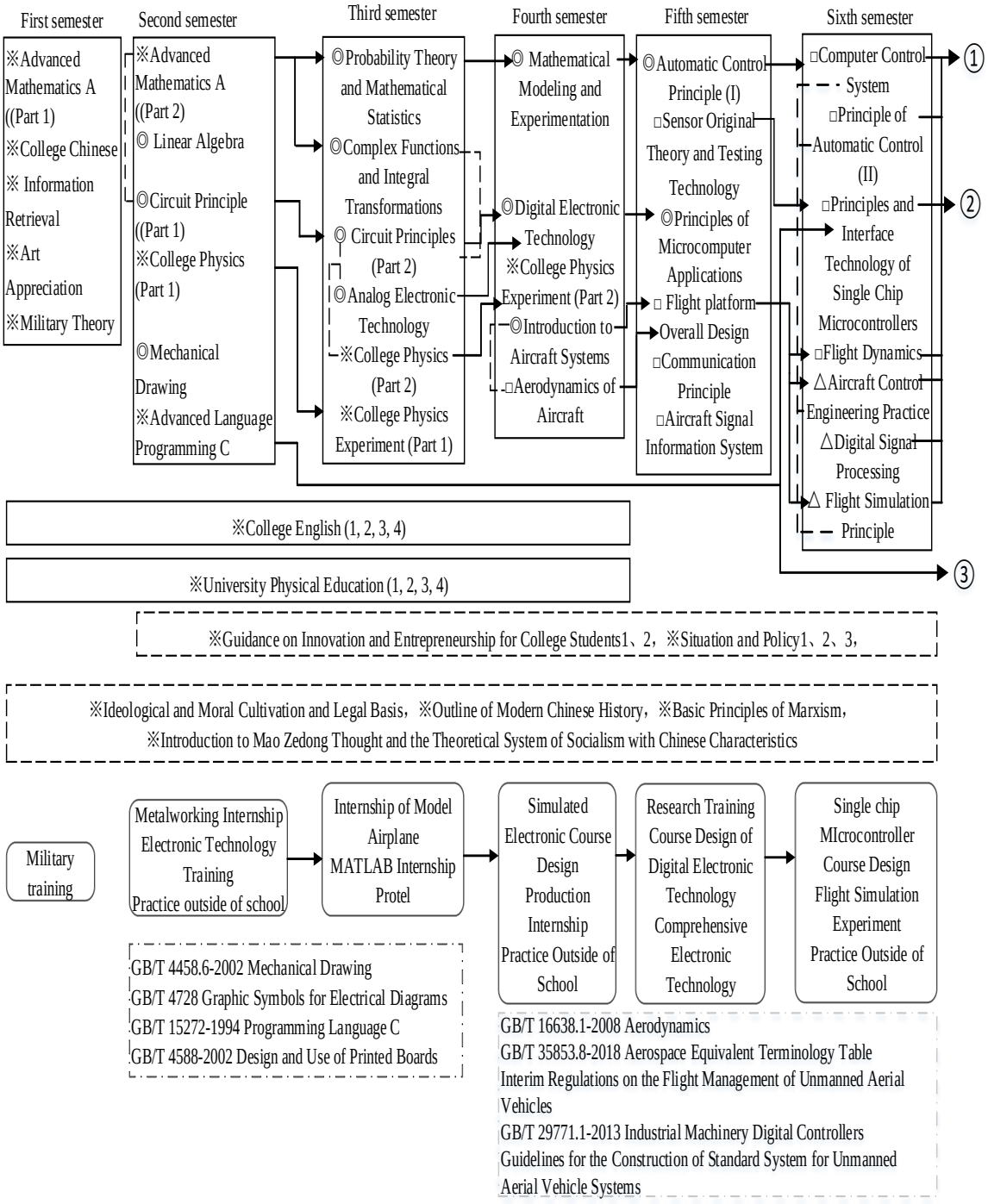

Figure 5: Chart of curriculum system and course connection for semester 1-6.

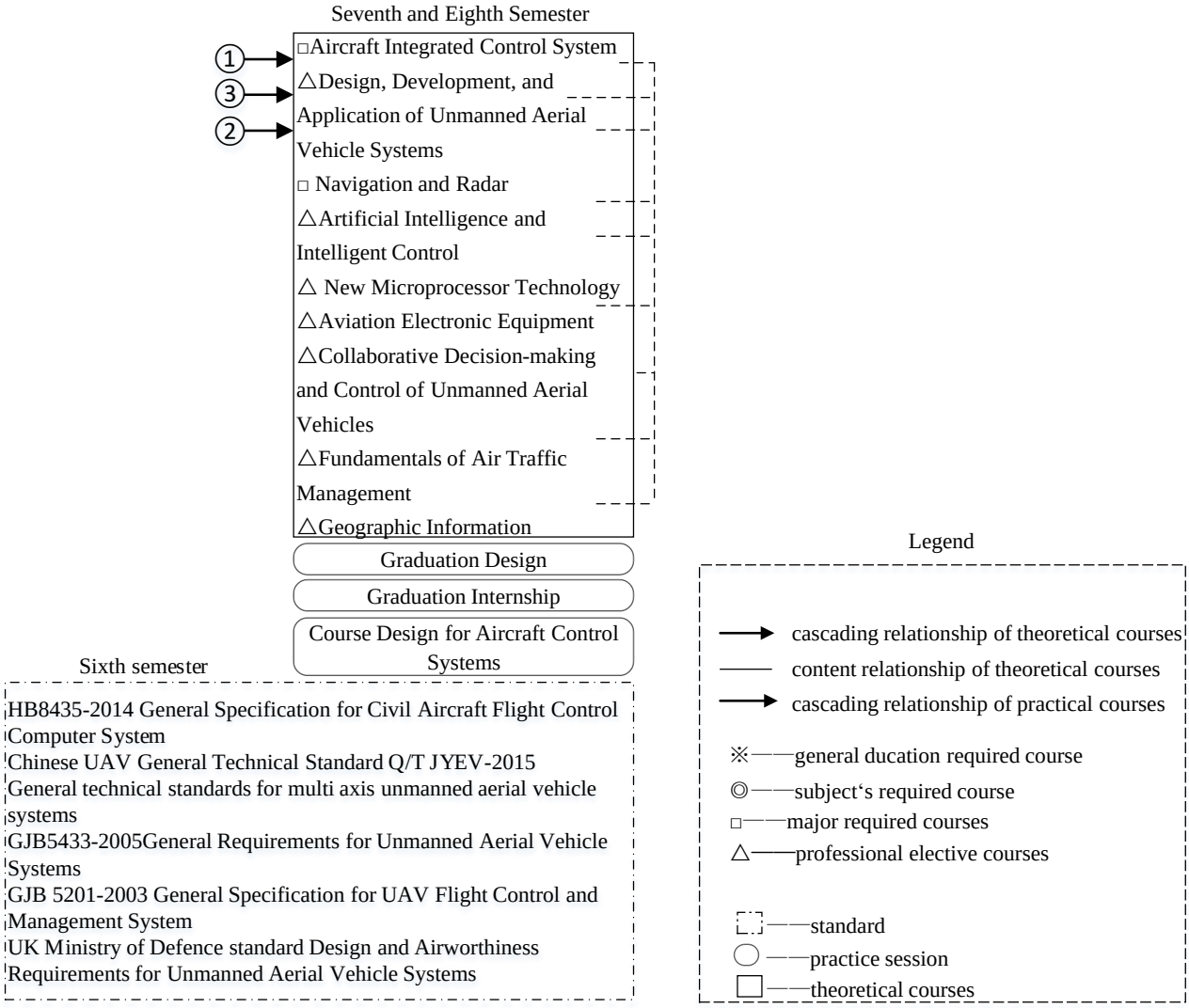

Figure 6: Chart of curriculum system and course connection and legend for semester 7-8.

4.2. Content of Course

As can be seen from Figure 5 and Figure 6, whenever there is a cascade relationship between courses in different semesters, there is a feedforward relationship between some contents of the courses in the subsequent semesters and the contents of the previous courses. There is an interrelated relationship between the course contents in the same semester, but it is not a cascade relationship. Because there is a cascade and feed-forward relationship between the four modules, it will be beneficial to the study and application of the course content if the content of the first course is added to the content of the subsequent course and the relationship between the course contents is established.

Take the relationship among Advanced Mathematics, Automatic Control Principle and Aircraft Integrated Control System as an example. Automatic Control Theory will apply a lot of knowledge of Advanced Mathematics, and there is a strong correlation between the two courses. In fact, if we don't realize the relationship between Advanced Mathematics and Principles of Automatic Control, it will lead to students' fear of difficulties when learning Advanced Mathematics and Principles of

Automatic Control, which will make it difficult to achieve ideal teaching results. For example, when establishing the UAV state equation of UAV mathematical model, we need the knowledge of differential equation of Advanced Mathematics. In this way, when teaching Advanced Mathematics, teachers can establish the relationship between the two courses by taking the UAV state equation as an example, which will play a good learning effect. The course "Aircraft Integrated Control System" needs the knowledge of "Automatic Control Principle". If we combine "Automatic Control Principle" with "Aircraft Integrated Control System", the course content will not be divorced from the specific application. Teachers should firmly grasp the teaching emphasis and depth required for the major, so that students can clearly understand the necessity, importance and practicability of learning the course of Automatic Control Principle. In addition, the mathematical content of Integrated Aircraft Control System is less, and the related mathematical knowledge in Automatic Control Principle is relatively difficult. It is necessary to establish the relationship between the two courses to improve the learning purpose, enthusiasm and initiative. The accelerometer, magnetometer and barometer sensors in the Integrated Control System of Aircraft are all designed and applied according to certain physical principles. In the course of College Physics, some principles about these sensors can be explained, which can avoid the boring and difficult problems when learning College Physics. On the contrary, students can learn in a targeted way. Many contents of Linear Algebra are applied in Aircraft Integrated Control System and Digital Image Processing, such as Euler angle, quaternion and direction cosine matrix of UAV attitude representation, Robert operator, Sobel operator and Prewitt operator in Digital Image Processing, etc.

In addition to the military training practice in the first semester, the practice from the second semester to the eighth semester also has a cascade relationship. In Figure 5 and Figure 6, the technical standards involved in the relevant courses are given, and teachers can add some or all technical standards as appropriate. The contents of technical standards introduced into general ducation required course, professional basic courses, major required courses, professional elective courses account for 10%, 10%, 15% and 20% of the contents of their respective courses respectively. evaluation systems

4.3. Integrating Technical Standards into Assessment System

As shown in Figure 5 and Figure 6, the assessment system integrating technical standards is a talent training scheme with technical standards as the measurement index, which integrates technical standards into theoretical teaching, practical teaching, curriculum design, graduation design and other teaching links. Let technical standards become a method of standardization in practice teaching. The assessment system mainly has four aspects: as a substitute for courses, grades are used as the assessment criteria for whether they are qualified or not and master the content they have learned. In universities, the course scores given can't truly reflect the students' real level to some extent, and the assessment scores are not enough to show whether they are suitable for the employment needs of enterprises. We develop and set up practical teaching platform and content with technical standards. The technical standards are considered as the main reference materials of the course. The content of graduation project should meet the technical standards, cultivate students' engineering consciousness

and better meet the needs of social enterprises. For theoretical courses, the proportion of technical standards introduced into general education compulsory courses, subject compulsory courses, professional compulsory courses and professional elective courses is 10%, 10%, 15% and 20% respectively. If the curriculum design, graduation design and other practical links are based on technical standards, then all reference technical standards can be introduced for assessment. In this way, graduates who meet the employment standards of enterprises will be trained in advance, and the needs of enterprises will be given priority, so that students will become the priority choice of enterprises.

5. Conclusion

In recent years, some colleges and universities have newly set up the unmanned aerial vehicle system engineering major, and these colleges and universities are exploring the talent training scheme of this specialty. Based on the actual situation of our country and our university, this paper makes a talent training scheme that integrates technical standards and cascade control theory. This scheme integrates the course system, course content and assessment mechanism of teaching quality supervision system based on cascade control theory, and strives to cultivate professionals who adapt to the current educational background of new engineering and engineering certification. The talent training scheme not only optimizes the course system and course content, but also establishes an effective assessment mechanism and a strict teaching quality supervision system, introduces technical standards to replace the examination system only with examination scores, and adopts an internal and external and double-loop control teaching quality supervision system to ensure the implementation and implementation effect of the talent training scheme. By making a talent training plan, the school makes students know which courses, the relationship between courses and the content of courses, so that teachers can timely supervise the effect of students' learning and whether it is reasonable and correct. The talent training scheme in this paper can be used as a reference for other engineering majors and schools.

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