Reasoning Research on the Integrated Teaching of Higher Mathematics and Automation Courses in Colleges and Universities

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ABSTRACT
Many courses of automation major in colleges and universities are theoretical and difficult to teach and study, which is undoubtedly a great challenge to teachers and students. Based on many years of experience in teaching automatic control principles, modern control theory, robot control and other courses in colleges and universities, the relationship between higher mathematics and automation professional courses, and how to integrate higher mathematics and professional courses with specific knowledge points are discussed. The work aims to provide a reference for the teaching practice of automation courses and higher mathematics in colleges and universities. Firstly, the overview of advanced mathematics and automation courses are presented. Then the integrated teaching of higher mathematics and automation is given, combined with the knowledge point in linear algebra and robot control. In the end, the integration of higher mathematics and professional courses teaching is discussed.
Keywords: *Colleges and universities, automation, advanced mathematics, basic courses, professional courses*

1. INTRODUCTION

With the rapid development and wide application of artificial intelligence and intelligent control, automation has become one of the most popular majors in colleges and universities. Many colleges and universities in China have set up automation major, which mainly cultivates the comprehensive development of knowledge, ability and quality, master the basic theory, basic knowledge and professional skills in the field of automation, and engages in engineering design, technology development, system operation management and maintenance, enterprise management and decision-making, scientific research and teaching in automation related fields high quality, comprehensive automation engineering talents[1].

The students of this major mainly study the engineering technology foundation and certain professional knowledge in a wide range of fields such as electrical technology, electronic technology, control theory, information processing, etc. they have the basic ability of automation system analysis, design, development and research, high comprehensive quality, and solid theoretical foundation and innovation ability[2]. It is not difficult to find that many automation professional courses are theoretical, difficult to learn, and require a high degree of mathematical knowledge. If there isn't a good foundation in the basic courses such as advanced mathematics for freshmen and sophomores, it will be very difficult to learn the professional courses such as automatic control principle, modern control theory and robot control in the third and fourth grade. Teachers and students have to spend a lot of time reviewing the knowledge points in higher mathematics involved in teaching professional courses, which will undoubtedly greatly sacrifice the professional courses valuable school hours.

2. OVERVIEW OF ADVANCED MATHEMATICS

2.1. The Importance of Higher Mathematics

Higher mathematics in Colleges and universities is a basic subject formed by calculus, linear algebra, geometry and its interdisciplinary content. Its main contents include sequence, limit, calculus, space analytic geometry and linear algebra, series, ordinary differential equation, etc.

As a basic science, higher mathematics has its inherent characteristics, that is, high abstraction, strict logic and wide application. Abstract and computationality are the most basic and significant characteristics of mathematics. Only when we have a high degree of abstraction and unity can we deeply reveal its essential law and make it more widely used. Strict logicality means that in the induction and collation of mathematical theory, no matter the concept and expression, or judgment and reasoning, we should use the rules of logic and follow the law of thinking. Therefore, mathematics is also a way of thinking. The

process of learning mathematics is the process of thinking training.

The progress and development of human society are inseparable from the wide application of mathematics. Especially in modern times, the emergence and popularization of electronic computers make the application field of mathematics more extensive. Modern mathematics is becoming a powerful driving force for the development of science and technology, and also widely and deeply penetrated into the field of social science[3].

2.2. Teaching Situation of Advanced Mathematics

First of all, higher mathematics courses are offered in science and engineering and economics and management majors in colleges and universities, but the textbooks tend to emphasize their own theoretical system, and the arrangement of contents is mainly based on the deduction and proof of theories and formulas. Therefore, the classroom teaching mode of higher mathematics is relatively fixed.

Secondly, in the curriculum reform, most colleges and universities have reduced the class hours of higher mathematics courses, obviously showing the characteristics of fewer class hours and more content. In order to complete the teaching tasks required by the syllabus within the specified class hours, it is difficult for teachers to let students participate in classroom interaction, and there is no time to talk about many complex engineering cases. Finally, the classroom has basically become a pile of definitions and theorems, making the course boring and boring, and the classroom is lifeless, and students have lost their interest in learning. Moreover, the use of unified teaching materials and the same teaching mode without considering the differences of different professional types and personnel training needs makes students of different majors and different cognitive levels often copy mechanically and rote in the learning process, and cannot flexibly use the mathematical abstract thinking mode to deal with some professional related practical problems, and cannot achieve the expected teaching effect For the expected abstract thinking, logical reasoning and other thinking ability training also has little effect.

Therefore, it has become one of the important problems for higher mathematics teachers to actively carry out the teaching mode innovation and teaching system research to meet the training requirements of different professional types of talents.

3. OVERVIEW OF AUTOMATION COURSES

3.1. Importance of Automation Courses

There are many automation professional courses, this paper only selects three typical professional courses of automatic control principle, modern control theory and robot control to elaborate. These courses have high requirements for mathematical knowledge. Only on the basis of mastering the relevant mathematics, can students follow the teaching ideas of teachers, learn the essence of these professional courses thoroughly, and lay a good foundation for the follow-up professional skills[4].

The automatic control principle is a technical science to study the common law of automatic control. It is an automatic regulation principle based on feedback theory, which is mainly used in industrial control. During World War II, in order to design and manufacture aircraft and marine autopilots, artillery positioning systems, radar tracking systems and other military equipment based on feedback principle, the development of automatic control theory was further promoted and improved. After World War II, a complete and mature automatic control theory system has been formed, which is the classical control theory based on transfer function. It mainly studies the analysis and design of single input and single output linear constant system.

Modern control theory is a kind of control theory based on state space method, which is a main part of automatic control theory. In modern control theory, the analysis and design of control system are mainly through the description of system state variables, also known as state space method. Compared with the classical control theory, it can study not only single input single output system, but also multiple input multiple output system. It can study not only linear system, but also nonlinear system, not only steady system, but also time-varying system. Therefore, modern control theory can deal with more extensive control problems than classical control theory. The method and algorithm used in this method are more suitable for digital computer. Modern control theory also makes it possible to design and construct optimal control system with specified performance index.

Robot control is an interdisciplinary subject in mechanical, control, electrical and electronic engineering, computer science and other fields. The main contents include: brief introduction of main components and subsystems of robot; representation of object space position; forward and inverse kinematics solution of robot; statics analysis and force control technology of robot and its operation; planning and design of robot operation path and driving control system. The teaching purpose of this course is to make students have a clear concept of robot technology. Master the robot kinematics, statics, dynamics calculation and motion planning design methods, and have a general understanding of the mechanical structure and the motion control design of the drive system of the industrial robot.

Understand the robot sensor, robot control, robot programming, robot application, and establish the complete concept of robot system.
In addition to the three courses, the automation major has many professional courses, and most of them are closely related to advanced mathematics. Here we will not introduce them one by one.

3.2. Teaching Situation of Automation Major Courses

Automation is a typical engineering specialty, and also one of the core specialties related to artificial intelligence and intelligent manufacturing. The basic theory courses of automation specialty often need to use the knowledge of mathematics, physics and natural science synthetically, which is difficult to teach. Most classroom teaching still adopts the traditional teaching method, that is, teachers teach knowledge to students according to the knowledge system structure in teaching materials, so as to help students construct knowledge system. However, this teaching method is obviously difficult to stimulate students' interest, arouse their enthusiasm, and is not conducive to the cultivation of students' critical and inquiry thinking.
In recent years, the university classroom teaching reform to improve teaching quality and stimulating learning interest has been paid attention to the education circle. Various teaching reforms such as MOOC, micro class and flipped classroom are popular in China. The first mock exam is to break the traditional mode of classroom teaching and make students become the protagonists of the class in a diversified way, so as to enhance students' learning effect in the classroom. However, the effectiveness of these teaching models depends on the high degree of interaction among students in the classroom. However, Chinese college students are accustomed to receptive learning, and do not easily express their own views in the classroom, which leads to the phenomenon that some students can't absorb and internalize the classroom content. According to the characteristics of the course and automation, how to design the course reasonably is a problem worthy of attention.

4. INTEGRATED TEACHING OF HIGHER MATHEMATICS AND AUTOMATION

In the teaching of higher mathematics, taking the knowledge point of matrix in linear algebra as an example, the teaching is carried out in this way. Based on teaching determinants, the knowledge points of matrix are extended.

4.1. Matrix Teaching in Linear Algebra

Example 1. An airline has opened several routes between four cities A, B, C and D. the flight chart between the four cities is shown in Figure 1, and the arrow points from the origin to the destination.

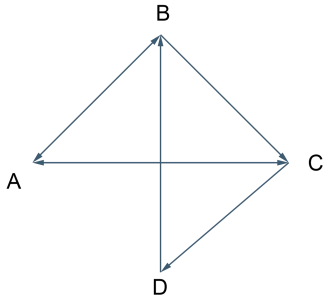


Figure 1. Flight chart between cities

For convenience, if 1 is navigable and 0 is not navigable, the flights between cities can be shown in Table 1.

Table 1. Flights between cities

	A	B	C	D
A	0	1	1	0
B	1	0	1	0
C	1	0	0	1
D	0	1	0	0

This table reflects the traffic connection between the four cities and can be written in the following form

$$M = \begin{bmatrix} 0 & 1 & 1 & 0 \\ 1 & 0 & 1 & 0 \\ 1 & 0 & 0 & 1 \\ 0 & 1 & 0 & 0 \end{bmatrix}$$

Then the general matrix can be given with an arbitrary number of rows and columns. Based on the definition of the matrix, we can teach the operation of matrix, mainly including the addition, subtraction, multiplication and inversion of matrix. After learning this part, under the guidance of the teacher, students can basically master the relevant content of matrix and solve some related problems.

4.2. Teaching of Kinematics in Robot Control

From the perspective of robot kinematics, see the importance of matrix knowledge in engineering application. Taking the arm type industrial robot as an example, the matrix can be used to represent points, vectors, coordinate systems, translation, rotation and transformation, as well as objects and other moving elements in the coordinate system.

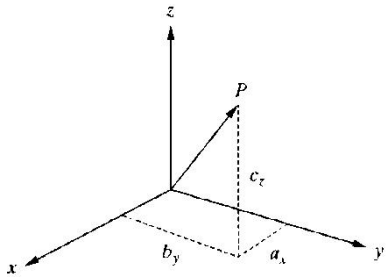


Figure 2. Representation of space vector

As shown in Figure 2, assuming that the end effector of the arm type robot is in the position of *P*, the three components of vector *OP* can be written in the form of vector, as shown in Figure 2.

$$\overline{P} = \begin{bmatrix} a_x \\ b_y \\ c_z \end{bmatrix}$$

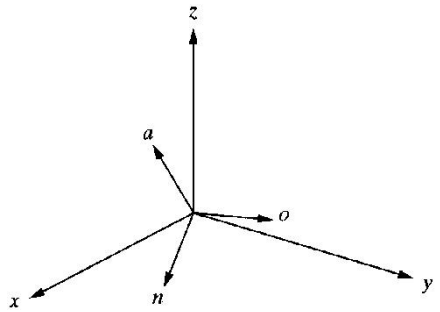


Figure 3. Representation of coordinate system at the origin of reference coordinate system

Suppose that the coordinate system *noa* fixed at a joint of the arm robot is represented by three components of the reference coordinate system *xyz*, as shown in Fig. 3. Therefore, the coordinate system *noa* in the reference coordinate system *xyz* can be expressed by three vectors in the form of matrix

$$F = \begin{bmatrix} n_x & o_x & a_x \\ n_y & o_y & a_y \\ n_z & o_z & a_z \end{bmatrix}$$

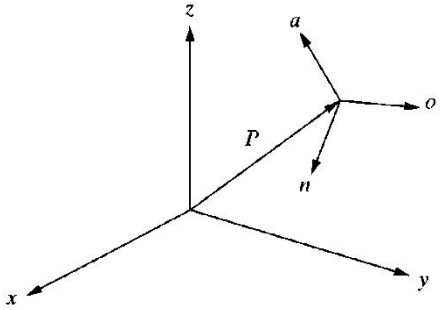


Figure 4. Representation of Space pure translation transformation

Since the direction vector does not change in the pure translation, the transformation matrix T can be simply expressed as

$$T = \begin{bmatrix} 1 & 0 & 0 & d_x \\ 0 & 1 & 0 & d_y \\ 0 & 0 & 1 & d_z \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Where d_x, d_y, d_z are the three components of the pure translation vector $\overline{d}$ relative to the *xyz* axis of the reference coordinate system. As you can see, the first three columns of the matrix represent no rotational motion (equivalent to the identity matrix), while the last column represents translational motion. The new coordinate system position is

$$F_{new} = \begin{bmatrix} n_x & o_x & a_x & p_x + d_x \\ n_y & o_y & a_y & p_y + d_y \\ n_z & o_z & a_z & p_z + d_z \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

The equation can also be written as

$$F_{new} = Trans(d_x, d_y, d_z) \times F_{old}$$

It can be seen from Fig. 5 that

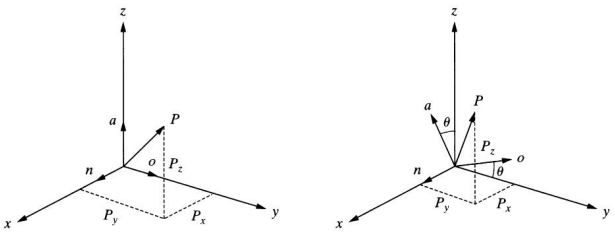
$$P_x = P_n$$

$$P_y = l_1 - l_2 = P_0 \cos\theta - P_a \sin\theta$$

$$P_z = l_3 + l_4 = P_0 \sin\theta + P_a \cos\theta$$

In the form of matrix

$$\begin{bmatrix} P_x \\ P_y \\ P_z \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos\theta & -\sin\theta \\ 0 & \sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} P_n \\ P_o \\ P_a \end{bmatrix}$$



a) Before rotation b) After rotation

Figure 5. Coordinates of points before and after rotation of the coordinate system

In this part of the content, the importance of Higher Mathematics in the follow-up professional courses is instilled in students. The matrix learned before is endowed with practical significance. The matrix can represent a series of movements of robot hand in space, which makes the boring mathematics vivid.

4.3. Integration of Higher Mathematics and Professional Courses Teaching

When learning linear algebra, students have established the basic concepts and contents of vector, matrix and matrix operation, and can use the knowledge to solve

related problems. On this basis, the robot kinematics is further studied. In this part, it aims to establish the connection between the boring matrix and the engineering practice. The matrix can be used to represent the position and motion of the end effector of the arm robot. For example, the matrix can be used to represent the point, vector, coordinate system, translation, rotation and transformation, as well as the objects and other moving elements in the coordinate system. In this way, combined with the engineering practice, boring matrix knowledge becomes vivid. Using matrix knowledge can easily make engineering problems mathematically, and it becomes more meaningful to solve engineering problems by using the learned mathematical knowledge. Therefore, for the students majoring in automation, we should pay attention to the integration in the teaching of advanced mathematics and robot control, which can be carried out from the following aspects [5]:

1. Adjust the course content of higher mathematics and improve the foundation of advanced mathematics for automation major

In the teaching process, in order to make the higher mathematics course adapt to the teaching needs of automation specialty, higher mathematics teachers can adjust the content of higher mathematics course appropriately. In this process, higher mathematics teachers should first combine with other teachers of automation specialty to understand the necessary higher mathematics content of automation specialty. Teachers of automation specialty can also set up professional basic courses linking their major with mathematics courses, such as introduction course of automation specialty, introduction of control engineering, etc., to teach the mathematical knowledge points used in the follow-up professional courses, so that students can better grasp the teaching content of the follow-up professional courses.

2. The teaching of higher mathematics is closely combined with automation specialty

The fundamental purpose of higher mathematics teaching of automation specialty is to lay a solid mathematical foundation for automation specialty. Therefore, in the process of higher mathematics teaching, the close combination of higher mathematics teaching and automation specialty can not only improve students' interest in learning higher mathematics, but also be closely combined with automation professional courses, so as to improve the rationality of higher mathematics course learning. Higher mathematics teachers should pay close attention to the dynamic development of automation technology, introduce the automation technology in the forefront of science and technology into higher mathematics classroom, realize the organic combination of higher mathematics teaching and scientific research, and make the higher mathematics teaching and scientific research closely combined.

3. Cultivate students' innovative thinking ability

In the process of higher mathematics teaching, cultivating students' innovative thinking ability can not only cultivate students' innovative consciousness and exploration spirit, but also cultivate students' knowledge reorganization and innovation ability. Higher mathematics teachers should pay attention to the cultivation of students' ability to observe things, lay a solid foundation for students' innovative thinking, pay attention to cultivate students' ability of guessing, encourage students to guess things boldly, so as to constantly stimulate students' thinking ability.

5. CONCLUSION

This paper discusses the integration of higher mathematics teaching method and automation professional course teaching, which can provide theoretical basis for the teaching mode reform of other similar majors. In classroom teaching, it is very necessary to stimulate the enthusiasm and initiative of students to participate in the course learning, and create a harmonious teaching atmosphere. It is of great practical significance to improve the quality of personnel training, students' innovation ability and comprehensive quality. In the process of teaching method reform, the necessity of teaching evaluation system reform should be considered. Only from the classroom teaching reform, course content system optimization, teaching team construction and other aspects to improve the classroom effect of the course, can the course really play the role of guiding students to have an interest in the industry.

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