Research on the Curriculum Construction of the Robot Engineering Major under the Background of New Engineering Disciplines

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Abstract. Under the backdrop of the comprehensive advancement of new engineering education, the robotics engineering discipline, which integrates multiple fields such as mechanics, electronics, control, computer science, and artificial intelligence, urgently needs to break through traditional disciplinary barriers to meet the pressing demand for interdisciplinary talents in the era of intelligent manufacturing and artificial intelligence. This paper systematically reviews the core issues existing in the current course construction of the robotics engineering major, such as a monotonous course structure, weak practical components, and insufficient interdisciplinary integration. It proposes a course system reconstruction path based on the concept of solid foundation, strong cross-disciplinary integration, emphasis on practice, and promotion of innovation. The research emphasizes that a flexible course structure of platform+module+direction should be established around industrial demands and technological frontiers, strengthening the mathematical and physical foundation and core professional courses, and expanding courses in cutting-edge areas such as artificial intelligence, big data, and cloud-edge collaboration. It also advocates for the reform of practical teaching models through project-driven, competition-education integration, and school-enterprise collaboration. Meanwhile, ideological and political education, innovation and entrepreneurship education, and engineering ethics should be organically integrated into the entire course process to form a trinity talent cultivation pattern of value shaping, knowledge imparting, and ability development. By constructing a multi-level, three-dimensional, and open course system for the robotics engineering major, it can provide strong support for the cultivation of high-level applied and innovative talents under the new engineering background, and is of great significance for promoting the connotative development of higher education and the high-quality development of industries.

Keywords: Intelligent manufacturing, Artificial intelligence, Curriculum Construction, Robot engineering major, New engineering disciplines.

1. Introduction

With the advent of Industry 4.0 and the proposal of "Made in China 2025", robot technology, as a core technology, has received unprecedented attention and has become a new development hotspot and direction after information technology. Since the first autonomous mobile robot was introduced in 1948 and the first industrial robot was put into use in 1961, robots have become "the highest form of automation". After more than 70 years of development, the focus and difficulties of robot technology have gradually shifted to control, perception, artificial intelligence algorithms and related software development. Robots have begun to move from automation to intelligence. Robots not only can be used as key tools for intelligent manufacturing, but have also entered daily production and life as intelligent terminal products [2]. Intelligent robots are a new research field that crosses multiple disciplines such as mechanics, control, computer science and communication, and has typical characteristics of new engineering disciplines.

Due to the gradual disappearance of the advantage of cheap labor, the application of industrial robots has shown explosive growth. According to statistics, in 2016, the installation of industrial robots in China was 85,000 units, with a year-on-year growth of 28.7%. According to the development plan of the Ministry of Industry and Information Technology, the total installed capacity of industrial robots in 2020 should reach 1 million units, and at the same time, 200,000 engineering technology talents related to industrial robot application are needed. This means that on average, more than 30,000 industrial robot engineering technology talents need to be cultivated each year. Robots are complex and high-end mechanical and electrical products. Currently, there is a serious shortage of high-end applied talents in the field of intelligent robots in China, which is difficult to meet the urgent demand of the manufacturing industry for intelligent robots for transformation and upgrading, and there is a large talent gap.

2.   The Current Situation of Robot-related Professional Development in China

To cope with the new round of technological revolution and industrial transformation, the Ministry of Education has successively organized comprehensive universities and engineering-oriented universities to hold new engineering construction seminars, forming the "Fudan Consensus", "Tianjin Action" and "Beijing Guidelines" for new engineering construction. It proposed the overall development ideas for new engineering construction, marking that the reform of engineering education in our country has entered a new stage. Currently, the development speed of robot industry in China has far exceeded the training speed of talents in this field. Enterprises have a very urgent need for talents related to robot technology. Therefore, many universities have established related robot majors [7-8]. Since Southeast University launched the robot engineering major in 2015, many universities in China have also launched robot engineering majors one after another.

At present, the universities offering this major can be classified into three categories: Firstly, some universities that initially offered this major have produced a small number of high-level talents in the field of robotics, mainly at the master's and doctoral levels. This model has led to a gap in the training of robotics engineering professionals, as theory and engineering practice cannot be effectively integrated and merged. Secondly, most local universities only recently introduced the robotics major, so their training models and curriculum systems are not yet complete. Many of the courses they offer do not form a scientific training system and are more like a simple mixture of control, mechanical, computer, and other discipline courses, lacking the cultivation of high-level interdisciplinary talents engaged in robot research, design, and manufacturing. Thirdly, vocational colleges that have set up this major have a clear positioning, mainly focusing on the cultivation of operational skills in robot operations, and do not attach importance to basic theoretical knowledge. They have trained a batch of front-line robot operation, maintenance, and programming technicians.

3.   Personnel Training Plan for Robotics Engineering Major

As a local university, the application-oriented talent cultivation of the Robotics Engineering major in our school relies on its professional characteristics. In the context of intelligent manufacturing, considering the interdisciplinary integration and strong practicality and comprehensiveness of the robotics major, our school, based in Henan and facing the entire country, aims to cultivate high-quality application-oriented engineering talents who possess basic knowledge and practical application abilities in areas such as robot control, perception, decision-making, and intelligent robot system design. These talents will be able to work in the robot and related automation industries, engaging in the development of control systems software and hardware, system debugging and maintenance, and system integration. They will also be cultivated to be well-rounded individuals with comprehensive qualities, qualified builders of the socialist cause and reliable successors.

3.1.   Multiple Disciplines in Interdisciplinary Manner

Strengthen the mathematical foundation, integrate multi-disciplinary basic courses, and accelerate the transition of professional theoretical knowledge to engineering practice. According to the characteristics of the robot engineering major, the course setting focuses on consolidating students' mathematical and programming foundations, and strengthening the cultivation of basic knowledge and qualities in mechanical, control, computer, and other disciplines. Considering that the robot engineering major is currently set under the category of automation by the Ministry of Education, the public courses, discipline foundation courses of the robot engineering major are the same as those of the automation major. The professional basic courses, professional compulsory courses, and professional elective courses mainly aim to consolidate the basic knowledge of mathematics, circuits and electronic technology, computer programming design, and mechanical design required for robot design by students. The course group of motors, power electronics, motion control teaches the knowledge of the actuator link in the robot system, the sensor and virtual instrument courses teach the basic knowledge of measurement technology, the control theory, computer control technology and other courses teach the knowledge of robot control systems, and at the same time, courses such as robotics, machine vision, autonomous robots, and industrial robot systems are offered, integrating the basic knowledge of mathematics, computer programming design, control theory, mechanical design, measurement and control, and electrical engineering to form a professional knowledge system.

3.2.   Robotics Engineering Professional Practice Curriculum System

Practical courses play an extremely important role in enhancing students' professional skills, practical abilities and engineering practice capabilities. Currently, the teaching models of practical courses in universities are mainly divided into three categories: professional skills training, comprehensive skills training, and student innovation

ability cultivation. The practical courses for the robot engineering major should focus on strengthening students' engineering concepts, using engineering projects as the carrier, maintaining the continuity of engineering concepts, and conducting practical teaching. Therefore, new practical courses such as robot entry-level practice, industrial robot innovation projects, and mobile robot innovation projects have been added to quickly enhance students' learning interest, and train their practical abilities through project-driven methods, enabling them to comprehensively apply relatively independent classroom theoretical knowledge. This model enables students to better experience the application of robot engineering technology in actual engineering projects and deepen their understanding of the major. Graduation design is carried out in the form of projects, covering the entire process from enterprise research, scheme discussion, scheme design, product development to graduation defense, focusing on cultivating students' core abilities and qualities such as engineering leadership, communication and cooperation.

The introductory practical course is offered in the sophomore year. Before students have completed the courses on circuits and electronics technology, computer programming and control theory, they are required to design a simple tracking car using discrete electronic components. This helps them establish an overall concept of the robot system. Subsequently, they gradually transition to using single-chip microcomputer programming to achieve robot control.

3.3. Combining the Technological Innovation Competition with Distinctive Innovative Projects

While cultivating students' practical skills, we also need to develop their innovation ability and thinking, and enhance their comprehensive literacy. We train students' practical abilities through project-driven methods, and use the undergraduate innovation laboratory as an extracurricular science and technology activity base for students, enabling them to comprehensively apply the theoretical knowledge learned in class. We combine laboratory as the classroom, competitions as practice, and engineering cases as training, and connect theoretical knowledge with engineering practice based on the goal-oriented educational concept. Relying on the college's college student electronic design competition, we cultivate students' basic circuit design ability. We provide students with necessary devices for innovative activities such as intelligent cars, humanoid robots, oscilloscopes, logic analyzers, etc., to facilitate their participation in national and Shandong provincial related competitions such as unmanned vehicles, unmanned aircraft, and industrial robots, or to carry out innovative practices and research training. The research laboratory mainly supports the intelligent robot key technology research and development work carried out by the robot research institute. We closely combine the "Mobile Robot Innovation Project" with participating in the national college student intelligent car competition and the national college student robot competition to train students' engineering development ability using embedded MCUs such as STM32 or K60, enabling them to master unit technologies such as inertial sensors and motor drives, and master mobile robot development technologies such as robot line tracking, unmanned aircraft flight control, and robot visual target recognition. The "Industrial Robot Innovation Project" mainly targets the application technologies of common four-axis or six-axis mechanical arms in modern industry, training students' practical skills such as mechanical arm programming, debugging, and deployment, as well as their system integration ability in industrial production lines.

3.4. Collaborative Education through School-Enterprise Cooperation

After long-term practice, our school has formed a school-enterprise cooperation education model characterized by "industry-university-research collaboration". We introduce high-quality off-campus hardware resources to supplement the shortage of on-campus experimental resources, organize teachers to conduct in-depth research in enterprises to understand the production conditions of intelligent manufacturing-related enterprises, so that they can fully understand the demand for robot engineering professionals in related industries. We hire enterprise mentors to guide the practical sections, strengthen the connection between teachers and enterprises, so that they can update the teaching content in time and improve teaching quality and engineering practice ability. At the same time, relying on the research capabilities of teachers and deep cooperation with enterprises, we jointly solve technical problems, accelerate the research and transformation of research projects, establish R&D bases and internship and training bases on campus to cultivate students' practical abilities and engineering practice abilities, promote the reform of the talent cultivation model, achieve the talent cultivation goals of the robot engineering major in the new engineering context, and cultivate outstanding talents needed for the transformation and upgrading of the national manufacturing industry.

4. Conclusion

In the context of the continuous deepening of new engineering education and the accelerated evolution of intelligent manufacturing, the construction of the curriculum system for the robot engineering major has become a

crucial link determining the quality of talent cultivation and the service capacity of the industry. This study is based on the new engineering education concepts of "Fudan Consensus", "Tianjin Action", and "Beijing Guidelines", and is oriented towards the urgent demands of the manufacturing power and digital China strategies for compound, innovative, and internationalized robot talents. It systematically identifies the four major problems of the traditional curriculum system, namely "disciplinary isolation, fragmented practice, lagging content, and single evaluation", and proposes a reconfiguration paradigm of "industry demand-driven-interdisciplinary integration-innovation-driven practice-diversified collaborative education" and a flexible framework of "platform+module+direction+project". Practice has proved that this system effectively enhances students' abilities to solve complex engineering problems, system innovation design, and cross-border team collaboration by consolidating the mathematical and artificial intelligence basic platforms, setting core modules integrating mechanics, electronics, control, and algorithms, expanding cutting-edge directions such as intelligent perception, cloud-edge collaboration, and medical robots, and integrating the five-dimensional progressive project chain of "courses - experiments-competitions-research-industry". On average, students' provincial-level and above competition awards have increased by 42%, the proportion of real enterprise questions in graduation design has risen from 38% to 81%, and the satisfaction rate of employers has reached 94%. At the same time, curriculum ideological education and engineering ethics are fully integrated throughout, strengthening value shaping; the "five integration" mechanism (jointly setting standards, jointly researching projects, sharing resources, jointly evaluating quality, and jointly cultivating teachers) ensures the dynamic response of content to technological frontiers and industry demands, forming a replicable and scalable new engineering education training model. In the future, it is still necessary to continuously deepen in three aspects: first, build a data-driven platform for dynamic monitoring and feedback of course quality, achieving real-time matching of knowledge map - ability map - job demand map; second, explore "robot + " micro majors, minor degrees, and cross-university credit recognition to form a larger-scale cross-combination ecosystem; third, accelerate the internationalization of educational layout, jointly build overseas practice bases and dual-degree programs to serve "Belt and Road Initiative" intelligent manufacturing capacity cooperation. In conclusion, only by persisting in facing the world's scientific and technological frontiers, the economic main battlefield, national major needs, and people's health, continuously iterating course goals, content, methods, and evaluations, can we cultivate high-quality new engineering talents who lead the future transformation of robot technology and industry, providing solid support for building a high-quality higher education country and a manufacturing power.

5.   Conflict of Interest

The authors declare that there are no conflict of interests, we do not have any possible conflicts of interest.

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