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Construction of an AI-based Curriculum System for Measurement and Control Engineering Program in Universities

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Abstract: With the rapid development of artificial intelligence (AI) and the continuous deepening of industrial digital transformation, Measurement and control engineering, as a core discipline bridging engineering practice and intelligent perception, should keep pace with the times and implement innovative reforms to its professional curriculum system. On this basis, in light of the talent demand of the measurement and control industry and the development characteristics of professional education in the AI era, this paper briefly analyzes the current situation of the construction of curriculum systems for measurement and control major in universities, and discusses the construction paths of an AI-driven curriculum systems for the program, so as to provide reference for the innovative development of education and teaching of measurement and control discipline in higher education institutions.

Keywords: Artificial intelligence; Measurement and control engineering; Construction of curriculum system

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1. Introduction

With the advancement of strategies such as Industry 4.0 and intelligent manufacturing, higher requirements have been put forward for the knowledge structure and practical abilities of talents in measurement and control engineering. Against this background, measurement and control engineering in institutions of higher learning should actively explore the organic integration of artificial intelligence and measurement and control education, reconstruct professional curriculum systems in line with the job requirements of intelligent measurement and control positions in enterprises, innovate talent training methods, improve course quality and students' professional skills, and strengthen their employability and career adaptability.

2. Talent demands of the measurement and control industry and vocational education development features in the AI era

2.1. Demand for talents in the measurement and control industry in the AI era

With the extensive application of artificial intelligence technologies in the field of measurement and control, the measurement and control industry is transforming toward high precision, intelligence and networking, and the competency requirements for measurement and control professionals have evolved accordingly. In addition to mastering core professional knowledge of traditional measurement and control technologies, such as circuit principles, signal processing and measuring instrument design, practitioners also need to possess basic AI application capabilities and understand the integration logic between AI and measurement and control technologies [1]. Furthermore, they should be able to apply AI algorithms to solve complex problems in the measurement and control domain, with competencies in data processing, model construction and optimization, and interdisciplinary collaboration. Meanwhile, they need to have solid engineering literacy, innovative thinking, and continuous learning ability, so as to better cope with the rapid iteration of AI technologies and meet the development demands of the measurement and control industry.

2.2. Curriculum system construction and development characteristics of measurement and control engineering education

Traditional measurement and control engineering in universities focuses on cultivating students' theoretical literacy and practical competence. In the artificial intelligence era, institutions of higher learning should keep pace with the times and integrate digital literacy and AI technology application capabilities into talent training objectives. On the one hand, most current curriculum systems of measurement and control majors are structured in the form of basic courses, fundamental professional courses, and core specialized courses, emphasizing the systematicness of professional knowledge. However, AI-related courses are only offered as elective or extended courses, which can hardly meet the industry's requirements for talents' AI application capabilities [2]. On the other hand, the teaching content of measurement and control majors includes a large number of verification experiments and engineering projects. With the increasing intellectualization of the industry, students need to acquire engineering practical competence in integrating AI technologies with measurement and control technologies during their campus study, which also puts forward higher requirements for the practical teaching of measurement and control majors [3]. In addition, interdisciplinary integration is the core development trend of measurement and control education. Professional teachers need to break the original disciplinary barriers, integrate teaching resources of different disciplines in universities, restructure the professional curriculum system that combines theory and practice in the AI era, and promote the in-depth integration of professional education and AI knowledge, so as to facilitate the high-quality development of measurement and control education.

3. Current status of curriculum system construction for measurement and control engineering in institutions of higher learning

3.1. Insufficient integration between course settings and artificial intelligence

At present, the curriculum system of measurement and control majors in many universities is still dominated by theoretical courses such as Error Theory and Data Processing, Principles and Applications of Sensors, Principles of Automatic Control and Design of Measurement and Control Instruments, while the provision of artificial intelligence-related course modules is relatively limited. For example, some colleges and universities only offer *Introduction to Artificial Intelligence* as an elective course. Its content is highly theoretical and has little relevance to measurement and control teaching, making it difficult to guide students to master the methods of applying AI technologies to solve measurement and control problems. In addition, the current curriculum system lacks a systematic integrated module of "AI + Measurement and Control", which prevents students from organically integrating and applying AI knowledge with professional knowledge of measurement and control, resulting in a disconnection between learning and practical application. For instance, when learning sensor technology, students can master traditional signal acquisition and processing methods, but do not know how to use machine learning algorithms to optimize and analyze sensor data.

3.2. Disconnection between practical teaching and industrial development demands

Measurement and control is a highly practical discipline, and practical teaching serves as a critical approach to cultivating students' engineering practical competence and innovative thinking. However, the practical teaching content of measurement and control majors in some colleges and universities is relatively outdated, with backward teaching facilities and a lack of information-based teaching modes. In terms of practical teaching content, most teachers deliver operation instructions of traditional instruments and verification experiments in accordance with course syllabi, and rarely involve AI-related practical projects, such as the design of intelligent measurement and control systems and the application of machine learning in data processing [4]. In terms of practical teaching facilities, constrained by funding and venue limitations, there is a shortage of intelligent systems, virtual simulation, and online training platforms, which fail to meet students' demand for repeated practical training. In terms of actual teaching modes, classroom experiments and on-campus training are the main carriers, while university-enterprise cooperation is not yet in-depth. Students can hardly gain access to real intelligent measurement and control projects in the industry, resulting in the slow development of their engineering practical competence.

3.3. Teachers' digital teaching ability needs to be improved

The teaching faculty serves as the fundamental guarantee for constructing the measurement and control curriculum system and enhancing the quality of talent training. At present, most teachers of measurement and control majors hold degrees in measurement and control-related disciplines, with solid professional knowledge and teaching competence in the traditional measurement and control field. However, they lack a systematic mastery of artificial intelligence knowledge and have a limited understanding of AI technologies and their industrial applications in the measurement and control sector. Consequently, they cannot independently develop integrated "AI + Measurement and Control" teaching content, nor do they have sufficient project resources to conduct comprehensive practical teaching for students. In addition, there remains considerable room for improvement in the professional development of measurement and control teachers in institutions of higher learning [5]. Due to the absence of systematic training on the pedagogical application of artificial intelligence, the improvement of teachers' digital teaching competence can barely keep pace with the advancement of AI technologies, which hinders the construction and development of the measurement and control curriculum system in the AI era.

4. AI-based curriculum system construction paths for university measurement and control majors

4.1. Optimization of course module setup and construction of an integrated curriculum system

A curriculum system of “AI + Measurement and Control” shall be constructed to meet the talent training needs of the measurement and control discipline. The concepts and technologies of artificial intelligence will be integrated into measurement and control courses, and the entire system will be divided into three modules: the public basic module, the professional core module, and the AI integration module. The public basic module aims to cultivate students’ basic literacy and knowledge, laying a foundation for subsequent professional study and comprehensive AI learning. Its main courses include Advanced Mathematics, Probability Theory and Mathematical Statistics, Engineering Mathematics, Fundamentals of Python Programming, College English and Ideological and Political Education. The teaching of Fundamentals of Python Programming and Engineering Mathematics should be strengthened: Python is the primary programming tool for artificial intelligence, while Engineering Mathematics provides a theoretical basis for AI algorithms and measurement and control data processing, which helps students build a solid foundation for their follow-up professional studies [6]. The professional core module covers the core content of the measurement and control major. While retaining classic traditional measurement and control courses, teachers should innovatively introduce course content related to artificial intelligence technologies. Main courses include *Error Theory and Data Processing*, *Principles and Applications of Sensors*, *Design of Measurement and Control Instruments*, *Digital Signal Processing* and *Embedded System Design* [7]. In practical teaching, teachers should appropriately integrate AI knowledge and skills. For example, content on deep learning-based sensor signal denoising and feature extraction can be added to the *Principles and Applications of Sensors* course, enabling students to understand the close connection between sensors and AI technologies while mastering traditional professional knowledge, and gradually form an interdisciplinary knowledge system. The AI integration module is a key innovation of the measurement and control curriculum system, designed to cultivate students’ ability to apply artificial intelligence to solve measurement and control problems. Universities can offer courses such as *Introduction to Artificial Intelligence*, *Fundamentals of Machine Learning* and *Design of Intelligent Measurement and Control Systems*, to introduce students to the basic concepts, development history, core technologies of AI and their industrial applications. Combined with specific cases, the system design ideas, development methods, and debugging techniques of intelligent measurement and control systems will be elaborated, so as to foster students’ capabilities in system design and development [8].

4.2. Innovate practical teaching modes and improve practical teaching quality

Traditional practical teaching mainly relies on practical operations such as data acquisition, processing and analysis, and system debugging to cultivate students’ hands-on ability. In the AI era, teachers should discard outdated practical teaching modes, add more AI-related practical projects, and construct a four-level practical teaching system consisting of basic practice, professional practice, comprehensive practice and innovative practice. In the basic practice stage, basic training programs such as Python programming and data processing are carried out to cultivate students’ fundamental skills. In the professional practice stage, practical projects including intelligent sensor application, machine learning algorithm implementation and debugging of intelligent measurement and control systems are launched to improve students’ professional practical competence. In the comprehensive practice stage, combined with real enterprise projects, comprehensive practices covering the planning, development, operation and maintenance of intelligent measurement and control systems are conducted to foster students' comprehensive application capabilities. In the innovative practice stage, students are encouraged to participate in innovation and entrepreneurship projects as well as academic competitions such as the National Undergraduate Electronic Design Contest and the Intelligent Measurement and Control Competition, so as to cultivate their innovative thinking and abilities [9].

For example, in the practical course *Fundamentals of Machine Learning*, students are required to implement algorithms such as linear regression and decision trees using Python to perform denoising, prediction and optimization on measurement and control data. This helps them intuitively understand the implementation logic of AI algorithms when processing complex measurement and control data, and deepens their comprehension of the integration of algorithm principles with professional application scenarios. Meanwhile, universities should increase investment in practical teaching facilities and build intelligent integrated online training platforms to meet students' demands for AI-related professional practice. For instance, a virtual simulation platform for intelligent measurement and control can be constructed to simulate intelligent monitoring and control scenarios of industrial parameters including temperature, pressure and flow rate in a virtual environment, enabling students to master the design, debugging, operation and maintenance methods of intelligent measurement and control systems through virtual operations. In addition, AI development tools such as TensorFlow and PyTorch should be introduced to engage students in the development and practice of machine learning algorithms [10].

4.3. Development of teaching faculty and enhancement of teachers' digital teaching competence

First, universities should formulate comprehensive faculty training plans, and systematically arrange for measurement and control teachers to participate in AI-related training, seminars and advanced professional development programs, so as to enhance their AI knowledge base and digital teaching competence. For example, training on machine learning and deep learning can be organized, and industry experts and university scholars can be invited to deliver special lectures and share insights into AI development trends and teaching experience. This helps teachers update their AI knowledge in a timely manner, master the latest application directions of artificial intelligence in the measurement and control field, and explore more adaptable comprehensive teaching methods.

Meanwhile, universities should vigorously support teachers in carrying out teaching and research activities related to "AI + Measurement and Control", and apply teaching and research outcomes to teaching practice, so as to enhance the advancement and practical applicability of measurement and control teaching [11].

Second, universities should actively recruit high-level interdisciplinary talents in the fields of artificial intelligence and measurement and control, invite engineering and research experts from measurement and control enterprises to serve as industry mentors, optimize the structure of the teaching faculty, and improve the quality of practical teaching [12]. Measurement and control teachers can be organized to take temporary secondments in enterprises and participate in the research, development, operation and other work of intelligent measurement and control projects. This will enrich teachers' engineering practical experience, translate real industrial cases into classroom teaching content, and avoid disconnection between teaching and industrial practice.

4.4. Improve the evaluation system and establish a core competence orientation

A diversified teaching evaluation mechanism shall be established, and a scientific evaluation system integrating process evaluation and outcome evaluation shall be constructed to foster a virtuous cycle in the reform of the measurement and control teaching system. Process evaluation accounts for 40% to 50% of the total score, which mainly assesses students' performance in classroom performance, homework completion, laboratory reports, practical operations and project progress. For example, in course teaching, students' theoretical learning is evaluated through classroom questioning, group discussions and homework completion; in practical teaching, students' practical competence is tested through practical operations, lab reports and project presentations. Outcome evaluation accounts for 30% to 40% of the total score, which is mainly implemented through final exams and graduation projects [13]. On the one hand, teachers should continuously optimize the content of final exams, reduce knowledge points relying on rote memorization, and add comprehensive questions such as case analysis and project design, focusing on assessing students' ability to apply theoretical knowledge and AI technologies to solve measurement and control problems. On the other hand, graduation projects should focus on students' comprehensive application ability and innovative ability, requiring the design to integrate practical problems in fields including artificial intelligence and measurement and control with certain practical value and innovative merit [14]. In addition, a comprehensive competence assessment accounting for 10% to 20% of the total score shall be added to evaluate students' innovative ability, team collaboration ability and engineering practical competence. For instance, students' achievements in academic competitions and innovation and entrepreneurship projects can be included in the evaluation scope, to encourage students to actively explore the application of integrated technologies and stimulate their intrinsic motivation to improve core competence.

5. Conclusion

In conclusion, with the advancement of artificial intelligence technologies and the development of the measurement and control industry, the AI-based curriculum system for measurement and control majors in universities requires continuous optimization and improvement. University teachers should further promote the in-depth integration of artificial intelligence and measurement and control. They shall continuously update course content, introduce new industrial technologies and methodologies to meet emerging industry demands, innovate practical teaching modes, and deepen the organic integration of AI technologies and practical teaching. These efforts will enhance students' engineering practical competence and job adaptability, and lay a solid foundation for their future employment or in-depth research in related industries.

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