



Teaching Reform of Intelligent Robot Principles and Practice Course

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Abstract. Intelligent robots refer to a new generation of robotic systems that integrate perception, decision-making, and execution capabilities. To meet the demands of the intelligent robotics industry for talent, we develop the course "Principles and Practice of Intelligent Robotics". The course content primarily covers the concepts, development, and societal impact of intelligent robots, as well as the software and hardware usage methods for modules such as motion, perception, and communication in intelligent robots, along with comprehensive design and implementation methods for intelligent robots. The course emphasizes the evaluation of practical skills, focusing on cultivating engineering practical abilities and innovative thinking of students. This paper provides a detailed account of the reforms and practical measures implemented in terms of course objectives, teaching content, and assessment methods, aiming to offer reference for the development of similar courses.

Keywords: Educational reform, Intelligent robots, Student cultivation, Industrial demand, Practical skills

1 Introduction

Intelligent robots are a new generation of robotic systems that integrate artificial intelligence, sensor technology, control engineering, and mechatronics^[1]. They possess four core capabilities: environmental perception, real-time decision-making, autonomous execution, and continuous learning^[2, 3]. Developing intelligent robots is not only an effective means to enhance production efficiency and ensure production safety, but also a key support for advancing smart manufacturing and intelligent services^[4, 5]. The rapid rise of the intelligent robot industry has led to an explosive growth in demand for high-level, multidisciplinary professional talent. Therefore, establishing an intelligent robotics curriculum system closely aligned with the needs of the industry is of critical practical significance, and it will provide a solid support for the sustained innovation and high-quality development of the intelligent robotics industry.

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Currently, the existing cultivation program of Intelligent Science and Technology major in our college faces several issues and problems. (1) There are still shortcomings in the depth and breadth of course content, while the integration and coordination between theoretical and practical instruction, as well as between courses, are not sufficiently tight. (2) The content and methods have not kept pace with industrial development, and there is a lack of specialized courses tailored to the needs of the intelligent robotics industry, leading to a mismatch between talent supply and industry demand.

Regarding reforms in intelligent robotics teaching, Feng establishes a feedback system linking robot assembly tasks with material handling robots to enhance teaching effectiveness [6]. Wang emphasize demand-oriented approaches and establishes innovative practical platforms for robotics education [7]. Zhang develops a virtual simulation humanoid robot practice platform for students to enhance the teaching and scientific research [8]. Huang makes a forward-looking analysis on the future development direction of the intelligent robots curriculum system, provides a framework to cultivate professional talents that meet industry needs [9]. Klomp proposed a modular and low-cost open education robot to help schools, teachers, and students learn robot technology more conveniently [10].

Based on the background and thorough research, we develop an artificial intelligence-based robotics course. It covers the concepts, key technologies, and application of intelligent robots. We adopt teaching modes such as blended learning and gamified learning, as well as evaluation methods that emphasize practical skill assessment. The aim is to provide students with a learning experience that combines theory and practice and to cultivate high-quality applied talents for the industry.

The paper is organized as follows: Section 2 introduces the design details of the course, Section 3 introduces the teaching and learning outcomes, Section 4 is the course improvement, the conclusion is introduced in Section 5.

2 Course Designing

2.1 Course Overview

Principles and Practice of Intelligent Robotics is an elective course for students major in Intelligent Science and Technology. The course content will help students master the basic theories, methods, and technologies of robots, improve their ability to solve practical problems, and lay a foundation in robotics technology for further study and future work.

2.2 Course Objectives

This course has two learning objectives, which incorporate ideological and political education elements to help students apply intelligent robot technology correctly.

Objective 1: Understand the concept, development, and application of intelligent robots, clarify the positive and negative impacts of intelligent robots on human society, and understand the proper methods for using intelligent robots.

Objective 2: Understand the principles and application of robot sensors, actuators, controllers, software frameworks, intelligent control methods, etc.; master basic methods for selecting and designing intelligent robot system hardware and software, and ultimately utilize the acquired knowledge to develop an intelligent robot system for designated tasks.

2.3 Teaching Methods

2.3.1 Classroom Lectures.

Classroom lectures enable students to master the theories and principles of intelligent robots, thereby laying the foundation for applications, the features are shown as follows:

- (1) Using heuristic teaching methods to stimulate students' interest in learning, cultivate them to analyze and solve problems.
- (2) The teaching process combines electronic lesson and multimedia teaching to enhance the intuitiveness of teaching.
- (3) A specialized case analysis section is included, centered on the design and implementation of intelligent robot, to cultivate their ability to write experimental reports, clearly state their views, and answer questions.

2.3.2 Experimental Lectures.

Experimental lectures cultivate students' ability to apply classroom knowledge to research and solve complex engineering problems, the features are shown as follows:

- (1) Experimental units are scheduled after theoretical lectures to help students apply the principles to actual robot systems and enhancing their understanding of the knowledge.
- (2) Experiments are conducted in groups, with students independently writing corresponding experiment reports. This approach ensures that each student masters the use of intelligent robot modules while fostering teamwork skills.
- (3) The experiment includes a comprehensive robot design component, cultivating students' ability to complete designated robot designs according to specific requirements.

2.4 Teaching Content

This course is designed based on extensive research into domestic and international courses in the field of intelligent robotics. The specific content is shown in Table 1, and the course content structure is shown in Figure 1.

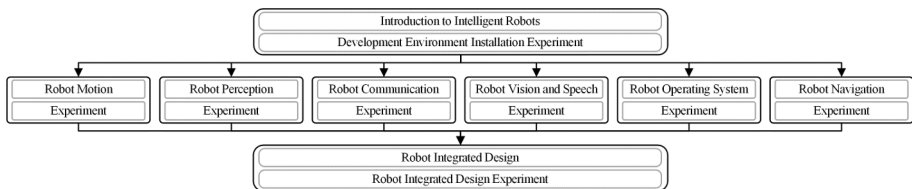


Fig. 1. Course content structure

Table 1. Course Content Arrange

No.	Teaching Unit	Teaching Content	Theoretical and Experimental Class Hours
1	Introduction and overview	Basic concepts and development of intelligent robot, its positive and negative impacts.	2/2
2	Robot Motion	Concepts of robot motion systems, its hardware foundations and control methods.	2/2
3	Robot Perception	Concepts of robot perception systems, its hardware foundations and usage.	2/2
4	Robot Communication	Concepts of robot communication, the hardware foundation and their usage.	2/2
5	Robot Vision and Speech	Concepts of robot vision recognition and speech systems, their hardware principles and usage.	2/2
6	Robot Operating System	Concept of the Robot Operating System (ROS) framework and its usage.	2/2
7	Robot Navigation	Concepts of robot navigation systems, its hardware principles and the usage.	2/2
8	Robot Integrated Design	Design and implementation methods for intelligent robots.	2/2

Overall, this course adopts a introduction-body-conclusion structure for teaching. Firstly, students will know about the introduction and overview of the intelligent robots. After that, the course covers six major modules to teach knowledge. Finally, This course teaches comprehensive design methods. This structure enables students to master the use of software and hardware through experiments, and ultimately complete the task of designing and implementing a specified robot.

2.5 Experimental Setup

We establish a hardware platform for this course. The platform is cost-effective, structurally simple, and equipped with various sensors, actuators, and controllers, meeting the learning requirements of this course. It also lays a solid foundation for students' daily studies, post-class experiments, final exams, and participation in academic competitions. Additionally, the course has developed an illustrated experimental manual that covers robot assembly, troubleshooting common issues, essential program code, and experimental details, effectively supporting students' independent learning.

2.6 Safety Dducation

To ensure that the experiments are carried out safely, we also include education on the safety aspects of the experiments:

(1) Electricity Safety: Use standard power supply, and forbid the use of broken wires; make sure the power is off before connecting the circuit to prevent short-circuiting.

(2) Battery safety: Check the appearance of the battery before and after the experiment, and stop using it immediately when bulging or leaking; strictly prohibit over-discharging, short-circuiting or placing it in high-temperature environments.

(3) Mechanical safety: Ensure that the motor is firmly fixed, it is strictly prohibited to touch the gears, axle or try to brake when the motor is rotating; test in an open, barrier-free area.

(4) Operation norms: Disconnect power after the experiment; be familiar with the location and use of fire extinguishers, immediately disconnect power when find smoke or overheating .

The purpose of this course is to cultivate students to establish “safety first” engineering ethics and standardized operating habits, thereby prepare a solid foundation for safety for future work in robotics research and development.

2.7 Grade Evaluation

The grade evaluation primarily focus on assessing their mastery of key knowledge and application skills. The evaluation consist of two components: regular and final assessments. The regular assessments focus on abilities in teamwork and report writing, in which students need to submit experimental reports to demonstrate their understanding of the principles and application methods of robot modules. The final assessments focus on abilities to independently complete, in which students need to answer the questions about the usage of robot modules and the selecting of sensors, actuators, and controllers to complete the design of robots. Through these assessments, this course maximizes students' understanding of technical principles and their ability to apply them to solve real problems.

2.8 Course Highlights

The main features of this course are as follows:

(1) Dynamic course framework: A flexible course content update mechanism is established, ensures that the course remains aligned with the latest developments of the industry.

(2) Practical project-driven: Challenging practical projects have been designed with the needs of the industries to enhance the interdisciplinary innovation capabilities.

(3) Blended Learning: Offline classrooms focus on theoretical learning, case analysis, and team collaboration, while online classrooms utilize the “Xuexi Tong” platform to provide course resources, forming a complementary learning ecosystem.

(4) Gamified Learning: Assessment incorporates game elements (such as robot racing competitions and task challenge competitions) to stimulate students' interest in learning and enhance their problem-solving and team collaboration skills.

(5) Tiered Instruction: Foundational experiments focus on knowledge units, comprehensive design encourages students to collaborate to design intelligent robot, and

the innovative phase guides students to participate in research or competitions, thereby cultivating their research and innovative capabilities.

2.9 Diversity and Inclusion

This course emphasizes diversity and inclusion, it is structured with varying levels of difficulty. Both the theoretical and experimental components of the course have been designed to cater to students of different levels. For students with a weaker foundation, completing the basic experiments will enable them to master foundational robotics knowledge (e.g., component usage, basic principles of various modules). For students with additional capacity, we also prepare advanced knowledge and assessment content (e.g., integration with deep learning, designing robots with complex functions) to help these students better grasp the course material. Through this design, students of different levels can learn corresponding knowledge, thereby enhancing teaching effectiveness.

3 Teaching and Learning Outcomes

3.1 Students' Outcomes

After completing the course, students designed and built robots independently based on given task requirements. The results of their work are shown in Figure 2.

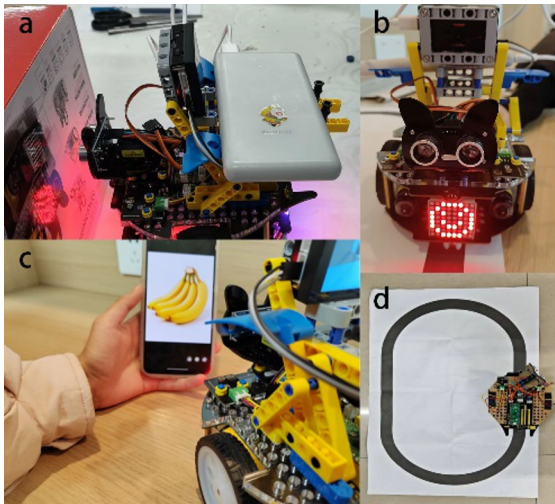


Fig. 2. Students' Outcomes. a) Obstacle avoidance task, b) Display task, c) Image recognition task, d) Line tracking task.

Through the design and implementation of robots, students have gained a basic understanding of how to use the various modules of intelligent robots and how to design them comprehensively, laying a foundation for their future careers.

3.2 Students' Grades

The grades of the students who taught last time are as shown in Figure 3. It should be noted that this is the previous teaching result, which is different from the updated assessment method.

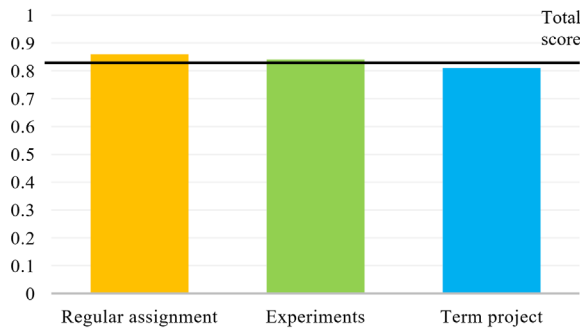


Fig. 3. Students' grade

The Regular assignment requires students to design a robot with a specific purpose (no implementation is required), which mainly examines the robotics concepts; Experiments is the average grade of 8 experiments, which examines the usage of individual modules; and Term project requires students to design a number of robots that are capable of accomplishing given tasks. The results indicate that the average grades are good, and the teaching objectives have been achieved. However, it should be noted that the students' grades are higher in usual grades, followed by the experimental grades, while the final grades are the lowest, which indicates that the students have a good mastery of each module, but are not capable of comprehensive application, pointing out the direction of improvement.

3.3 Teaching Evaluation

The student evaluation results for the last round pedagogical are shown in Table 2.

Table 2. Student Teaching Evaluation Results

Item		Score
Course scores (actual/full)	Overall scores	89.58/100
	Teaching methods	13.34/15
	Teaching content	17.74/20
	Assignment guidance	8.89/10
	Teaching attitude	18.16/20
	Teaching Aids	4.30/5
	Learning gains	27.15/30
College average		86.67/100
School average		85.88/100

The student evaluation results show that the overall course score is 89.58, which indicates that the course content meets students' learning requirements and the evaluation score is higher than the college or school averages. It should be noted that the course's teaching methods score is lower than other items (86%), indicating that the teaching methods should be improved.

4 Course Improvements

Based on industry development trends, changes in market demand, teachers' teaching experiences, and student evaluations, we made revisions to the course content and teaching methods to ensure that talent cultivation remains highly consistent with industry development. The specific improvements are as follows:

In terms of course content, the sections on robot vision and speech recognition have been reduced from 4 class hours to 2, while the content on the Robot Operating System (ROS) has been expanded. The reason for this revision is that the principles of visual and speech recognition are covered in courses such as deep learning and natural language processing. Additionally, as ROS is a hot technology in the field of intelligent robotics, it is necessary to shift from a simple overview to a more in-depth focus on ROS, thereby better aligning with industry demands and effectively enhancing students' employability.

In terms of teaching methods, leveraging the advantages of educational digital technology, this course will build a digital and intelligent learning platform based on existing course resources. Utilizing the "Xuexitong" platform, the course will record video lectures on key knowledge points and deliver them through online teaching, experimental demonstrations, and micro-courses, enabling students to access knowledge and skills anytime, anywhere, and improve learning efficiency.

In terms of long-term evaluation of the course, as students have not yet graduated (expected graduation in 2026), we cannot obtain information on their employment status or the extent to which the course has helped them in their work in the intelligent robotics industry. We will continue to track this in the future to help further optimize the course content.

5 Conclusion

The intelligent robotics industry is a key indicator of the nation's efforts to upgrade its manufacturing sector and enhance its core competitiveness. Against this backdrop, this study is grounded in industry-driven needs and has developed a artificial intelligence-focused robotics course. Until now, the course has completed its first round of instruction and received positive feedback. Through the course, students have enhanced their mastery of the skills required by the intelligent robotics industry, thereby expanding their career prospects. In the future, we will continue to improve the course in content and teaching methods.

Acknowledgements

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