Research on the Reform of ROS Robot Programming Experiment Course for Applied Undergraduate Artificial Intelligence Majors

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Abstract. Through artificial intelligence-oriented teaching and scientific research exploration, remarkable results have been achieved in consolidating professional basic education, promoting disciplinary innovation, and cultivating high-quality application-oriented talents. This major is a multidisciplinary integration of software and hardware based on mathematics, information theory, and computer science. It has rich professional connotations, wide application fields, and rapid development. Artificial intelligence is a strategic technology leading a new round of technological revolution, industrial transformation, and social transformation, and is having a significant and far-reaching impact on economic development and social progress. This paper mainly adds adversarial elements to the traditional application-oriented undergraduate artificial intelligence major ROS-related course experiments. It makes students' experiments more challenging, and the students they cultivate are more able to adapt to challenging tasks. Possess the ability of effective communication, field integration, and teamwork, and the ability to explore, analyze, apply research results, and solve systematic engineering problems.

Keywords: Applied undergraduate; ROS robot programming; Counteracting exercise.

1 Introduction

1.1 Background

Artificial intelligence is a new technical science that studies and develops theories, methods, technologies, and application systems for simulating, extending, and expanding human intelligence. It involves computer science, statistics, psychology, philosophy, and cognitive science. , neurophysiology, information theory, cybernetics, big data, and many other fields, is a marginal interdisciplinary subject and is currently mainly classified as a branch of computer science. Today, with the rapid development of information technology, artificial intelligence technology has achieved good development and made great contributions to my country's modernization drive. All kinds of schools have built artificial intelligence teaching experiments and training rooms through school-enterprise co-construction and other methods. Through professional technology, enterprises provide professional artificial intelligence teaching experiments and training platforms according to the characteristics of different schools and students at different levels and different use needs. And the training room is

ICMEIM 2023, September 08-10, Wuhan, People's Republic of China

DOI 10.4108/eai.8-9-2023.2340066

conducive to the cultivation of students' innovative consciousness and is also conducive to professional construction, teaching, and development.

The laboratory is an advanced educational concept of scientific research teaching, innovative education, experiential education, and project-based learning. It uses advanced science and technology such as mobile Internet, big data, image recognition, and the Internet of Things to build a curriculum system based on the integration of software and hardware. A comprehensive solution for innovative education based on core and event competitions. Through the establishment of courses that closely combine artificial intelligence and information technology disciplines, students' artificial intelligence literacy, cooperative inquiry spirit, and practical innovation ability are improved. The laboratory provides high-quality curriculum resources, scientific teaching aids, expert resources, and service guarantees for the development of intelligent education and teaching in schools so that the profound artificial intelligence technology can be understood by students in a simple and interesting way, and according to the learning characteristics of students of different ages and knowledge background, formulate challenging tasks and innovative themes, and encourage students to practice and explore independently.

1.2 Current challenges

As one of the most important interdisciplinary courses in the field of artificial intelligence, the ROS robot programming course occupies a very important position in the field of artificial intelligence. As an elective course for students in the fifth semester, the course has a total of 48 class hours, of which 16 class hours are for experiments. The preamble courses are Python programming and application, machine learning, deep learning, and Linux technology and application, and the follow-up courses are smart device development practice and artificial intelligence innovation development practice.

In traditional experimental courses, students mostly complete the experimental tasks in the form of tasks. The enthusiasm of students is not high, and the scoring criteria are based on student sign-in, experiment process, and experiment report. There is a lack of teamwork ability training and competition awareness among students. By introducing a competition mechanism, students can participate in experiments more actively, understand the working principle of ROS robots more deeply, and improve the effect of experiments.

1.3 Global progress

A survey of China's current relevant undergraduate colleges found that compared with research-oriented undergraduate colleges, application-oriented undergraduate colleges have no significant characteristics in personnel training, and even have homogeneity to a large extent. There is no obvious difference between the two types of colleges in terms of talent training programs and curriculum system design. Students in applied undergraduate colleges pay more attention to theory, lack the cultivation of students' autonomous hands-on ability, and lack confrontational and competitive courses. Reduce students' enthusiasm for learning. This course project mainly includes cultivating students' independent learning, through the combination of subject learning and competition, stimulating students' enthusiasm and subjectivity in learning, so that students can truly apply what they have learned.

The major of Artificial intelligence is a key major in the construction of "new engineering" in colleges and universities. Students trained in this major should have extremely high scientific literacy and strong innovation and entrepreneurship capabilities. Help students establish an overall understanding of the field of artificial intelligence, and lay a solid foundation for future research in various branches. [1] Utilize the high-speed computing power and super storage space of artificial intelligence in classroom teaching to prevent teachers from doing low-value-added work, save time and cost, and improve overall teaching efficiency. Most universities have expert systems to improve the educational environment by deploying information and communication technology (ICT) and intelligent systems. For the majority of students, artificial intelligence can more intuitively experience the process of abstract knowledge concretization, which improves the interest and motivation of learning, so that students can better accept and use knowledge.

As the underlying technologies continue to develop, AI will likely improve online learning, software for adaptive learning, and simulations by responding to and interacting with students more intuitively [2]. In recent years, with the continuous and rapid development of my country's higher education, various application-oriented colleges and universities have begun to shift the focus of education and teaching to the cultivation of "practical and applied talents". Therefore, the construction of undergraduate laboratories has become the key exploration of many colleges and universities. [3] The combination of classroom and experiment has gradually become the mainstream. However, there are problems in the research and application of artificial intelligence in the field of education, such as the narrowing and fragmentation of artificial intelligence applications, and the practice hours are often less in the learning process, while the theoretical hours often account for the majority, which will limit the development space of students. The understanding of artificial intelligence is only at the theoretical level, and it cannot be used flexibly and innovated. For a long time, my country has adopted the model of Western countries such as Germany in the construction of practical undergraduate courses. In the short term, this "bringing doctrine" can solve the problem of insufficient application-oriented undergraduate courses in my country, but in the long run, it cannot meet the country's expectations for the quality of applied talents in the era of intelligent manufacturing. [4] In addition, the content of these existing teaching syllabi is too old, and it is difficult to keep up with the pace of updating related industries and related technologies at home and abroad. Excessive theoretical study makes students less motivated to participate in various electronic competitions, and even fewer can complete tasks and win honors in the competitions, resulting in students gradually losing opportunities for training in competitions, which hurts the cultivation of applied talents. [5] Secondly, the context of AI education application is often set in a certain activity in the school education environment, such as AI-assisted teaching system, intelligent agent system, intelligent question answering system, etc. [6], in essence, for technology The upper layer ignores that the functional scope of artificial intelligence in the fields of corporate training, family education, continuing education, and special education is still limited. The future integration of artificial intelligence technology and all walks of life will drive the emergence of a large number of emerging industries. Support makes the future development of the artificial intelligence industry highly predictable, and poses contemporary challenges to the artificial intelligence professional education in colleges and universities. Before 2018, domestic artificial intelligence education focused on the cultivation of high-level talents, and no colleges and universities offered undergraduate majors in artificial intelligence. - Master-Bo" integrated talent training echelon. Although the

formation of this talent training echelon is conducive to the research and development and breakthrough of the source of artificial intelligence innovation, [7], how to reform the teaching content and teaching methods of artificial intelligence control courses is an urgent problem for every application-oriented university. The problem.

As the main practice field of "artificial intelligence + education", colleges and universities should continuously improve the layout of artificial intelligence disciplines, open more artificial intelligence-related majors, and systematically structure artificial intelligence-related discipline courses, and continuously promote artificial intelligence education through in-depth theoretical research on artificial intelligence practice. [8] According to the "Decision on Accelerating the Development of Modern Vocational Education", my country will vigorously develop the vocational education system in the future. By 2020, the scale of vocational education in my country is expected to reach one trillion people. With such a large market size, students must not only have sufficient professional knowledge but also have qualified professional skills and professionalism. How to make zero-distance contact between schools and enterprises, "move" the real needs of enterprises to the classroom, and realize "professionalism" "Docking with "professional" is the focus of future vocational education reform, [9] This is also a test for teachers. The classroom confrontation practice combined with artificial intelligence and ros can not only allow students to practice instead of learning but also stimulate students' innovative thinking while improving their hands-on ability. Based on practical problems, they will diverge vertically, prompting students to build a knowledge system, thereby improving students. Comprehensive ability.

To explore the core mechanism of artificial intelligence promoting educational development, it is necessary to reveal the law of interaction between technology, education, and society from the perspective of complex systems, explore the essential impact of artificial intelligence on educational development from the perspective of learning science, and use "history and culture" The perspective predicts the development trend of future education. [10]

2 Course Overview

2.1 ROS overview and development environment construction

This experiment mainly introduces the related concepts of the ROS robot operating system, the installation of the Ubuntu system in the VirtualBox virtual machine, the installation steps of ROS, the process of writing, compiling, and running the ROS program, the concepts of ROS nodes, topics, services, and parameters, and the ROS integrated development environment. Build, and finally summarize the design goals, development history, system architecture, etc. of ROS, as shown in Table 1.

2.2 ROS Common Components

This experiment mainly introduces common components of ROS. Some more practical tools are packaged for developers in ROS. The use of these tools includes TF coordinate transformation, rosbag, and rqt toolbox. Static or dynamic pose conversion in the robot system can be easily realized through TF coordinate transformation; rosbag can record and playback

data while the robot is running; the rqt toolbox is a collection of a series of tools, which can easily debug ROS programs and improve Program development efficiency, as shown in Fig. 1.

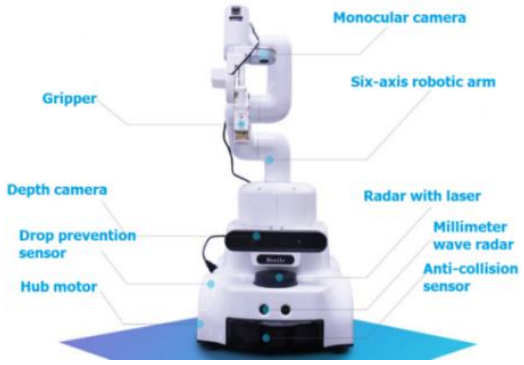

Fig. 1. ROS Robot

Table 1. Experimental content

	Experiment	Period
1	ROS overview and development environment construction	2
2	ROS Common Components	2
3	ROS Visual Programming and Mapping	2
4	ROS Autonomous Navigation and Obstacle Avoidance	2
5	Python programming control robotic arm overview and hand-eye calibration	2
6	Model training and target detection experiments	2
7	Object recognition and grasping	2
8	Autonomous Grasping Experiment	2

2.3 ROS Visual Programming and Mapping

This experiment mainly introduces how rivz provided by ROS realizes various data displays, how to use various display screens of rivz, and uses secondary development plug-ins to create a simulation environment. Introduce how BeetleRobert scans images through the binocular camera of ROS, and how to construct maps through SLAM, Cartographer, relaunch, and other algorithms.

2.4 ROS Autonomous Navigation and Obstacle Avoidance

This experiment mainly introduces the commands that ROS will use in the process of autonomous navigation and obstacle avoidance and the ROS communication mechanism. Through SLAM+Cartographer to build maps, rviz realizes Beetle's autonomous navigation and obstacle avoidance. The communication mechanism is one of the core contents of the ROS system. In the robot system, the data transmission between different modules depends on the communication mechanism. Communication between topics is also achieved by sending ROS messages between nodes.

2.5 Python programming control robotic arm overview and hand-eye calibration

This experiment mainly introduces the basic knowledge theory of Python, the basic grammatical rules, how to use Python programming to control the attitude of the robotic arm, learn to use Python programming to control the gripper, use ROS+moveit to program the motion planning of the robotic arm, and understand the theory of hand-eye calibration through OpenCV Knowledge, and learn the code logic of hand-eye calibration.

2.6 Model training and target detection experiments

This experiment mainly introduces two-stage target detection algorithms such as Overfeat, R-CNN, and MaskRCNN, and single-stage target detection YOLO, SSD, and other common detection algorithms for target detection methods, and selects appropriate algorithms to carry out corresponding training for the machine.

2.7 Object recognition and grasping

This experiment mainly introduces the knowledge points related to object recognition and grasping and the training of the machine in the early stage. In the simulation environment, relevant classroom training and teaching are carried out. Through an example, the combination of artificial intelligence, ROS, and robotic arm is fully demonstrated, so that students can master object recognition and Grab all the knowledge points covered and consolidate them.

2.8 Autonomous Grasping Experiment

This experiment mainly introduces the knowledge points of autonomous grasping and carries out relevant classroom confrontation in the simulation environment, including (scanning, map building, perception, path planning, autonomous cruise, robotic arm control) in the classroom to carry out relevant racing or grasping quantity red Blue confrontation, through the student confrontation display, fully demonstrates the combination process of artificial intelligence, ROS, and robotic arms, allowing students to master the comprehensive application of autonomous grasping, understand the knowledge points covered by the entire autonomous grasping, and use them flexibly.

3 Introducing competition into the experimental process

In traditional experiments, students achieve the experimental goals by completing tasks. In the course of practice, it is found that after introducing the group competition mechanism, the experimental effect has been enhanced.

In the classroom, there are two confrontation modes, one is a competition based on racing or confrontation, a group of 3 people competes, and the same number of squares (a total of 6) are placed on the public shelf and the lower layer and the group is used as a unit, the two groups are the red and blue teams to fight against each other. Within the preset 10 minutes, the red team or the blue team snatches the cube in the public area, recognizes the referee's designated cube before the game at the charging station and warehouse shelf and successfully grabs it. In

your own team's scoring box, arrive last in the warehouse shelf area and return to the starting area, as shown in Fig.2, Fig.3 and Table 2.

3.1 Python programming control robot arm overview and hand-eye calibration

Students can control the robotic arm through Python code, and use the knowledge of hand-eye calibration (to determine the pixel coordinates and the coordinate transformation of the space manipulator coordinate system), image processing, kinematics forward and reverse solutions, image calibration, and other knowledge to test the student's ability to control the camera in actual control. After the detected target finds the pixel position in the image, the pixel coordinates of the camera are transformed into the spatial coordinates of the manipulator through the calibrated coordinate transformation matrix, so as to control the manipulator to reach the specified position.

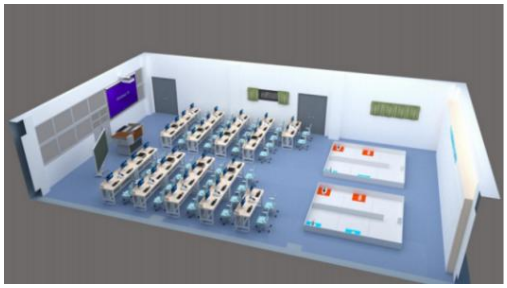

Fig. 2. Playing field and Classroom teaching real picture

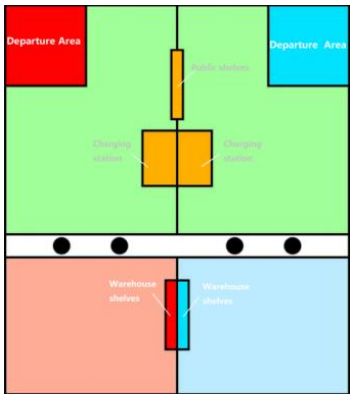

Fig. 3. Detailed areas of the competition venue

Table 2. Introduction to the detailed areas of the competition venue

	Experiment	Regional introduction
1	departure area	The departure area is the start and end timing area, where the red and blue opponents can carry out maintenance, inspection and testing
2	Public shelf area	The public shelves are divided into upper and lower layers, with three building blocks on the upper layer and five building blocks on the lower layer. If you successfully catch the building blocks, you will get 10 points

3	charging station area	There are red and blue color squares in the charging station. During the competition, students identify and grab the corresponding color wooden blocks according to the teacher's requirements. The successful grabbing is 15 points.
4	Warehouse shelf area	The warehouse shelves are divided into upper and lower floors. A total of 10 patterned building blocks are evenly placed. According to the teacher's requirements, identify and grab the corresponding color building blocks (three in total), avoid interfering building blocks, and get 25 points for successfully grabbing.

3.2 Autonomous grasping experiment

Through red and blue confrontation, students use ROS, robotic arms, vision, and other knowledge combinations. In terms of ROS, students use SLAM, Cartographer, relaunch, and other algorithms to build maps, rviz to realize Beetle's autonomous navigation and obstacle avoidance, and mechanical In terms of arms, students' grasping rate and hand-eye calibration ability are tested. In terms of vision, according to the previous visual training results, QR code, color, and pattern recognition are carried out. The combination of the three tests students' ability to use knowledge flexibly.

3.3 Experimental Scoring Criteria

The competition is divided into three areas, starting area, charging area, and warehouse shelves. Complete all items within ten minutes of the competition time, and use an autonomous cruise to return to the starting area smoothly. Before the start of the competition, the two sides have five minutes of preparation time. During these five minutes, they are not allowed to move the position of the building blocks. The debugging of the equipment can be completed on the field. When the competition starts, the students should start from the starting area and arrive at the public shelves. There are a total of Place 6 building blocks with a diameter of <3cm, fight against red and blue, and compete for building blocks on the shelf. Each building block is worth 5 points. After arriving at the charging card station, according to the teacher's requirements, identify the required building blocks (a total of two building blocks)), 10 points will be counted after successful picking, and then use ROS to automatically cruise to reach the warehouse shelf, use visual recognition to pick specific building blocks, one 15 points, a total of 3, and return to the starting area smoothly, the game is over.

Note: At the same time, compare the number of blocks, and compare the length of time when the blocks are the same. The number of cubes > the duration, 15 points will be awarded if the game is completed within the specified time, 5 points will be deducted for 1 minute overtime, and finally, the victory will be judged according to the number of points. The standard stipulates that the action accounts for 60%. Other points account for 40%.

4. Student Ability Cultivation

The design of this course focuses on cultivating students' enthusiasm and enthusiasm for independent learning, stimulating students to think about artificial intelligence issues, and discussing the content derived from artificial intelligence, so as to truly apply what they have

learned, and teachers and students can also communicate Teaching benefits each other, broaden students' knowledge, improve students' hands-on ability, and make students more enthusiastic about artificial intelligence learning. Group confrontation can also improve students' ability to communicate effectively, field integration, and teamwork. Let students discuss with each other, and keep growing. There is also a certain improvement in the ability to discover, analyze, and apply research results and respond to systematic engineering problems.

5 Conclusion and Outlook

The current artificial intelligence learning mode is mainly driven by data. With the development of science and technology, the application of the Internet in various fields has become the general trend and the application of "Internet +" artificial intelligence. Under the background of artificial intelligence, new requirements are put forward for the cultivation of talents in colleges and universities. As an applied undergraduate, it is necessary to pay more attention to the cultivation of students' quality, and to cultivate students ability to discover problems, do things independently, think independently, and innovate independently. This is the trend of applied undergraduates. It is also the direction of future development.

After the test, the experimental project is planned before the experiment starts every school year. After the experiment is carried out, the experimental process is checked, and finally, the mode of continuous improvement is achieved by summarizing after the experiment. In the long run, similar teaching methods will continue to be used to cultivate students with higher comprehensive qualities.

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