Research and Application of Data Structure and Algorithm of Vision Module Based on Intelligent Car

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Abstract. This paper is based on the intelligent car controlled by Raspberry PI 4B as the carrier, based on the Python language, the mainstream Jupter Lab as the software development tool. We analyzed the data structure and algorithm of the four core vision modules and discussed the application of the development of the vision module in the course design of data structure and algorithm analysis. Finally, through the revised TOPSIS evaluation model, the diversified comprehensive assessment of students can better evaluate the learning effect of students in the course.

Keywords: Intelligent car · vision modules · data structure and algorithm · TOPSIS

1 Introduction

Under the new situation of Industry 4.0 and Made in China 2025, "Made in China 2025" requires the cultivation of innovative and compound talents who have both theoretical knowledge and on-site practice, mastering both professional skills and inter-professional capabilities. The talent training model of software engineering requires the intersection of software majors, the compounding of software talents, and the intelligence of software technology, and the deep integration of intelligent software industry applications to cultivate high-quality "industry software development talents" to fill the complex of intelligent manufacturing talent gap.

"Data Structure and Algorithm Course Design" is an important practical link in cultivating students to apply data structure and algorithm knowledge to analyze and solve problems [1]. It plays an important role in improving students' comprehensive application of theoretical knowledge and collaborative spirit. Traditional course design projects have been unable to meet the requirements of "advanced innovative and challenging" and the talent needs of the intelligent software industry [2, 3]. Relying on the upsurge in the development of artificial intelligence software, data structure course design is also facing the adjustment of teaching methods.

Relying on the intelligent car as the carrier, through the research and implementation of the algorithm and data structure in its intelligent module, students can understand the

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application scenarios of modern industrial automation and adapt to the development of the intelligent software industry; at the same time, the TOPSIS model is used to assess students, which can clearly Reflect the learning situation of students, and carry out teaching reflection and improvement.

2 Research on Data Structure and Algorithm Based on Intelligent Car

2.1 Computer Vision Technology

The State Council pointed out in "Made in China 2025" that the primary purpose of my country's intelligent manufacturing in the next 10 years is to further improve productivity and production quality on the premise of liberating labor, and its core competitiveness is still relatively "fast" and "precise". Vision and image technology is one of the greatest human technologies in the 20th century [4]. 70% of the information people perceive the outside world is obtained through the eyes, and the amount of information contained in the image is the largest. Vision technology is widely used in the field of industrial robots and has four main functions:

First, guided positioning and visual positioning require that the machine vision system can quickly and accurately find the measured part and confirm its position, and use machine vision to position the loading and unloading materials to guide the robotic arm to grasp it accurately.

Second, appearance inspection, to detect whether there is any quality problem on the production line, this link is also the link that replaces the most labor.

The third is high-precision measurement. Some products have high precision, reaching 0.01–0.02 m or even u-level, which cannot be measured by the human eye and must be completed by a machine.

Fourth, recognition is to use machine vision to process, analyze and understand images to identify targets and objects of various modes, which can achieve data traceability and collection.

2.2 Combining Course Teaching with Computer Vision Technology

Mobile robots are relatively mature products in the current industrial automation field, and the smart modules involved in common visual smart cars are also the core business foundation of the current smart software industry. The course will be designed and developed with a visual intelligent car as a carrier. The complete development of the car involves the hardware and software parts. The design and development of the software part includes a large number of rich data structure applications and algorithm design.

The corresponding relationship between the simplified basic intelligent modules and intelligent manufacturing core technologies to be selected for the course is shown in the following Table 1.

Table 1. Correspondence between basic intelligent modules and core technologies

Intelligent module	Intelligent manufacturing core technology
Line-following mode	Guided positioning
Color inspection	Appearance inspection
Ultrasonic distance measurement	High-precision measurement
QRcode identification	Identification

Table 2. Smart module opic

Intelligent Module	Functional
Line-following modes	Cruise motion on a black line path on a white background
Color inspection	Complete the color tracking of the camera gimbal
Ultrasonic distance measurement	Complete the basic 3D Contour Measurement
QRcode identification	Aim the QR code at the camera, and the car will make corresponding movements after recognition

2.3 Course Design Content

The content of the course design is based on the intelligent car controlled by Raspberry Pi 4B as the carrier, which can support a variety of programming languages such as Python language (subsequent practice will be developed based on Python language), Open Source CV is the main image processing library, and mainstream Jupter Lab is a development tool that is easy for students to use. Most of the above intelligent modules use numerical matrices to express data logically and use classical image algorithm processing libraries to perform calculations, which are suitable for deep learning of the underlying language and extended design and development.

In the independent development of the intelligent module, it is carried out in groups of four. The specific intelligent module topics can be selected by themselves, and the teacher will make fine adjustments to ensure full coverage of the selected topics. The intelligent module selection topics are shown in the Table 2.

2.4 Course Teaching Arrangement

The teaching arrangement of this course is divided into 6 parts, including pre-class preview, in-class student practice and defense, and after-class summary report. In students' independent practice, based on software engineering thinking, students can experience the key links of the life cycle of intelligent software development, including four stages of requirements analysis, design, coding, and evaluation optimization. Taking the line-following mode as an example, the students' independent design and practice arrangements are as follows.

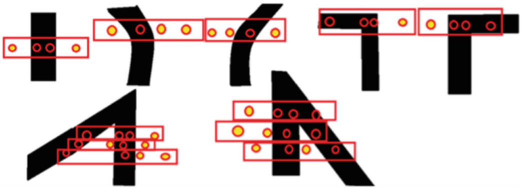

Fig. 1. Infrared sensor state diagram under straight line small bend right angle and acute angle.

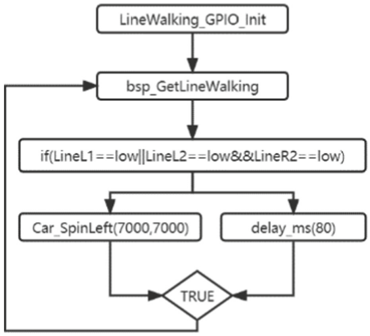

Fig. 2. Flowchart of the line-following mode algorithm.

(1) Requirements analysis
Students are required to analyze the driving adjustments that need to be made during cruising according to the different driving conditions of the car, and can roughly draw the functional structure diagram under road conditions such as single curve and single right-angle turning as shown in Fig. 1.

(2) Design
Students can abstract a specific and descriptive computing model based on the conclusion of the demand analysis, determine the data structure and related algorithm logic, and draw a clear main program execution flow chart, as shown in Fig. 2.

(3) Coding
Among them, LineL1 and LineL2 respectively represent the two infrared sensors on the left, and LineR1 and LineR2 respectively represent the two infrared sensors on the right; when both LineL1, LineL2 and LineR2 detect a black area, it means that the car has encountered a big left turn and needs to control the car to turn slightly to the left. The code screenshot is shown in Fig. 3.

(4) Evaluation optimization
Students can optimize the algorithm according to their own needs to expand the usage scenarios to achieve line patrol driving on more complex routes.

2.5 Course Assessment Based on TOPSIS Model

According to the course arrangement, the process of assessment is divided into three assessment stages, namely before class, during class and after class.

```
void app_LineWalking(void)
{
        int LineL1 = 1, LineL2 = 1, LineR1 = 1, LineR2 = 1;

        bsp_GetLineWalking(&LineL1, &LineL2, &LineR1, &LineR2);

        if( (LineL1 == LOW || LineL2 == LOW) && LineR2 == LOW)
  {
        Car_SpinLeft(7000, 7000);//turn slightly left
                delay_ms(80);//delay
  }
```

Fig. 3. The code screenshot of line-following mode.

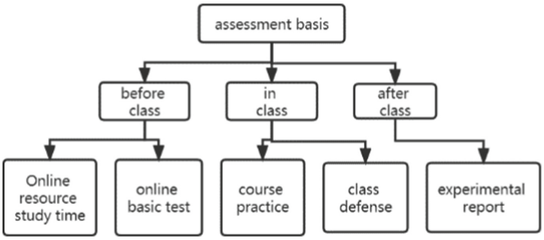

Fig. 4. The architecture of the evaluation.

(1) Assessment content

Before class: Students complete the preview of self-study materials, teachers can supervise statistics through the online learning platform, and students complete the basic knowledge test related to the project.

During the course: Students can complete the design and implementation of the selected module according to the four links of demand analysis, program design, coding test, and evaluation and optimization; submit the defense PPT according to the group for defense.

After class: Students organize and improve the experimental report in class. The architecture of the evaluation is shown in Fig. 4.

(2) Quantification of evaluation indicators of the TOPSIS model

TOPSIS (Technique for Order Preference by Similarity to an Ideal Solution) model can comprehensively evaluate individuals based on existing evaluation data. According to the above evaluation system, the teacher can obtain the evaluation vector of a student with a student number in the class as:

$$x(i) = [x_1(i), x_2(i), x_3(i), x_4(i), x_5(i)] \tag{1}$$

Among them, $x_1(i)$~$x_5(i)$ represent a student's online learning time, online basic test score, course practice score, defense score and experimental report score respectively.

(3) Modified TOPSIS model

Since the dimension and magnitude of different dimensions in Eq. 1 are different, the initial vector is preprocessed by the maximization method [6]. The index of each student needs to be divided by the maximum value of this index of all students, and its calculation method is shown in the following Eq. 2.

$$x_j(i)^* = \frac{x_j(i)}{max_i x_j(i)} j = 1, 2, 3, 4, 5 \tag{2}$$

Due to the relative evaluation system, the least outstanding students may have a grade of 0. Therefore, in the original TOPSIS model, the relative value is used when constructing the positive ideal vector, and the absolute value is used when constructing the negative ideal vector [5]. The corrected ideal vector NX is calculated as Eq. 3:

$$\begin{cases} PX = (px_j)_{1\times 5} = [max_i x_j(i)] = [1, 1, 1, 1, 1] j = 1, 2, 3, 4, 5 \\ NX = (nx_j)_{1\times 5} = [min_i x_j(i)] = \left(nx_j^*\right)_{1\times 5} = [0, 0, 0, 0, 0] j = 1, 2, 3, 4, 5 \end{cases} \tag{3}$$

According to the TOPSIS model, the distance between each student's assessment vector and the ideal vector needs to be calculated as Eq. 4:

$$\begin{cases} DP(i) = \sqrt{\sum_{j=1}^{5} (x_j(i)^* - 1)^2} \\ NP(i) = \sqrt{\sum_{j=1}^{5} (x_j(i)^* - 0)^2} \end{cases} \tag{4}$$

Combining the two distance information DP(i) and NP(i) of each student, the final assessment score of the student is a percentage system, and the final score s(i) is calculated as Eq. 5:

$$s(i) = \frac{NP(i)}{NP(i) + DP(i)} \times 100 \tag{5}$$

(4) Expected effect

The course teaching mode based on intelligent software development, while strengthening the training of the core knowledge of traditional data structures and algorithms, intends to achieve the following effects in the cultivation of applied talents:

The necessary links in the software development process, such as demand analysis, program design, coding testing, evaluation and optimization, are integrated in the experimental process, which reflects the comprehensive application of knowledge, technology, and methods, and is conducive to gradually cultivating the thinking of solving complex engineering problems ability [6].

The evaluation method based on the TOPSIS model is used to conduct diversified assessments for students, and the five evaluation indicators are integrated into the assessment plan, which can make up for the shortcomings of the traditional single evaluation method of courses, and can clearly reflect the students' learning in each course effect.

3 Conclusions

The application of the data structure and algorithm teaching mode based on the functional module of the smart car can meet the needs of "advanced innovative and challenging", improve students' engineering practice ability, and cultivate students' computational thinking ability and innovation ability. The evaluation method based on the TOPSIS model can meet the needs of process evaluation and effectively solve some problems in the course evaluation system. This teaching mode is still in the preliminary discussion, and it needs to be further practiced and improved in the later stage.

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Research on the Reform of Course Assessment and Evaluation System Based on "advanced innovative and challenging"–Take "Data Structure Curriculum Design" as an example (2021N030).

References

1. Dong C, Dai M (2020) Teaching reform and practice of data structure course based on OBE concept. China Light Ind Educ 2020(02):80–85+96
2. Xiang Y (2021) Hybrid teaching design and practice empowered by artificial intelligence—taking data structure and algorithm courses as an example. Software 42(02):46–51
3. Yang Q (2020) Discussion on the teaching of "Data Structure" course in the era of artificial intelligence. China Educ Inform 2020(24):48–51
4. Zou H, Lei H (2019) Research on the teaching reform of data structure courses under the background of artificial intelligence. Educ Mod 6(A4):56–58. https://doi.org/10.16541/j.cnki.2095-8420.2019.104.020
5. Zhou K, Shen S, Jin Y (2020) Research on a diversified assessment and evaluation model for mathematical modeling courses. J Zhejiang Univ Technol 48(02):202–206
6. Zhao X (2019) Analysis on the reform of talent training in the intelligent software industry. Comput Prod Circ 2019(09):95–96