Research on Teaching Reform of Machine Vision Course in Application-Oriented University

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Abstract. In the context of Industry 4.0, it is increasingly necessary to carry out undergraduate teaching of machine vision. Combined with the characteristics of this course and the characteristics of the intelligent manufacturing specialty in the application-oriented undergraduate colleges, the problems faced by this course in the early stage, such as the poor integration with the traditional mechanical specialty courses, the poor enthusiasm of students, and the limitations faced by the teaching content, were improved. The reform was mainly carried out from three aspects of teaching content, teaching mode and assessment method, and the curriculum objectives were evaluated. The degree of achievement exceeded 0.85. The curriculum after the reform was more popular with students, and more in line with the professional development and the training objectives of today's application-oriented undergraduate students.

Keywords: machine vision · application-oriented undergraduate · teaching reform · course objectives

1   Introduction

Vision sensor is widely used in various control systems because of its strong ability to obtain information and adapt to the environment, and it is easy to build automation and intelligence. This makes the research based on machine vision and visual servo control become a very important topic in the bachelor's thesis of intelligent manufacturing [1]. In addition to the continuous exploration of the direction of machine vision by the business community, colleges and universities are also constantly exploring the education space of machine vision, so as to achieve a smooth connection between production, teaching and research. The most obvious measure is that some colleges and universities have added the "machine vision and application" course in their undergraduate teaching [2]. In the case of limited machine vision class hours, how to improve teaching efficiency, teaching quality and cultivate students' practical ability poses a serious challenge to the teaching of this course [3]. Therefore, we propose reform measures from the aspects of teaching content adjustment, teaching mode innovation, assessment methods, etc. With the maturity of the automation industry and the increasing demand for talents in the intelligent industry [4]. This paper is based on the local two application-oriented undergraduate mechanical intelligent manufacturing specialty to explore the teaching reform measures and implementation effects of machine vision course [5].

2   Main Problems in Machine Vision Teaching

2.1   Weak Integration of Industry and Education

At present, the students' personal goals of local second level colleges and universities attach importance to "graduation exit" and emphasize free choice [6]. Under the new situation, China's education reform requires such colleges and universities to cultivate application-oriented talents to promote local economic development. As most of the high-tech industrial clusters and outstanding talents associated with machine vision are mainly distributed in the developed first tier and second tier cities, the applied undergraduate colleges in the third tier and fourth tier cities have insufficient power to integrate industry and education, and students cannot freely choose the "graduation way" in this region, reducing students' learning expectations.

2.2   The Curriculum System Cannot Be Fully Supported

At present, the undergraduate "machine vision and application" has a wide range of contents but is difficult. It is a four part principle of light, machinery, electricity and computation and its comprehensive application. When it comes to the knowledge of optical imaging and a lot of knowledge about algorithms, students need to learn a lot of knowledge that has not been learned in the early stage by themselves. Many universities, such as the Mechanical Engineering School of Zaozhuang University, do not have optical courses. There are few class hours, currently 48 class hours. Due to the large amount of content and difficulty, many students feel that their application ability cannot meet the actual engineering needs after learning, which leads to lack of confidence, and thus has a certain shake to the field.

2.3   The Students' Imagination and Creativity Cannot Be Brought into Play

Although a practical training course is also offered in colleges and universities to provide students with a practical training base for practice, they can only carry out experiments according to the relevant experimental instructions and follow the steps in the experiment, which is conducive to mastering knowledge points. This step-by-step teaching model can not give play to students' imagination and creativity. Students also lack interest in doing experiments, and the teaching effect can not be shown well. In the context of universal education, the quality of students in application-oriented undergraduate colleges in the third and fourth tier cities has deteriorated year by year, which is manifested by weak learning foundation, lack of interest in professional learning and lack of learning objectives [7]. When explaining the theoretical knowledge points of this course in class, it can be observed that the enthusiasm of students has decreased significantly, the classroom atmosphere tends to be dull, and the number of students taking notes in class is very small. After class, there are few students who can actively participate in professional learning in the non final examination stage. In this case, how to improve the teaching effect of machine vision course needs careful consideration [8].

2.4 The Assessment Method is Single, and the Teaching Effect Cannot Be Comprehensively Evaluated

The examination of machine vision course still continues the examination oriented education mode, which adopts the form of final examination paper examination plus usual grades. The final exam accounts for 70%, mainly examining the memory of theoretical knowledge points and formula deduction. However, when students encounter practical problems, it is difficult for them to understand the theoretical nature of the problems and apply what they have learned; The usual performance accounts for 30%, which is composed of three parts: attendance rate, usual performance and experimental results. The assessment is mainly based on teachers' understanding of students' individual performance. However, teachers have limited understanding of students and the phenomenon of average performance is serious.

The course assessment is generally "usual score" + "final exam score", which causes students to focus on the surprise before the exam, review relevant knowledge a few days before the exam, and recite the key points drawn by the teacher. However, I am lazy in class at ordinary times, just afraid of roll call, not enough time at ordinary times, and ignoring the widespread learning phenomenon at ordinary times [9]. It is difficult to play a guiding role in promoting knowledge internalization and improving innovation ability. Moreover, the original teaching effect evaluation mainly analyzes the statistics of scores, such as the average, maximum, number of failed grades and the distribution of scores [10]. However, according to the requirements of engineering education professional certification, the evaluation of teaching effect mainly reflects the achievement of curriculum objectives, and is an important data source for the achievement of graduation requirements. The original evaluation method is no longer applicable.

3 Measures of Teaching Reform of Machine Vision Course

According to the guiding ideology of engineering education professional certification, curriculum objectives are used to support the target points after the graduation requirements are refined. The achievement of curriculum objectives can be used as an internal factor to evaluate the achievement of graduation requirements. Therefore, graduation requirements are the starting point for setting curriculum objectives. For the machine vision course of Mechanical and Electrical Engineering College of Zaozhuang University, the corresponding graduation requirements and examination elements are shown in Table 1.

If the support degree of the secondary indicator point is high, the corresponding curriculum goal achievement value can be used to calculate the achievement degree of graduation requirements; Otherwise, it is unavailable. In the machine vision teaching syllabus of Zaozhuang University, the course objectives of this course are divided into four, corresponding to the secondary index points of No. 1–4 in Table 1.

Course objective 1: understand the basic framework of the machine vision system, be able to draw the block diagram of a given system, and analyze the working process and principle of the system.

Table 1. Support of Machine Vision Course to Graduation Requirements

No.	Graduation requirements	Secondary indicators	Support level
1	2. Analyze engineering problems	2.1. Key links and parameter expression	High
2	4. Research and experiment	4.2. Experiment implementation	High
3	5. Use modern tools	5.2. Use of tools	High
4		5.3. Application Development	Low

Course objective 2: master the basic algorithms of image processing, and understand the principles of two-dimensional Fourier transform, wavelet transform and other algorithms.

Course objective 3: to enable students to understand the value of image processing algorithms in specific application scenarios, and to achieve image analysis, processing and result display through MatLab programming, so as to train students' analysis and application skills for complex engineering problems.

Course objective 4: practice the programming tools (MatLab, Python, LabVIEW, etc.) learned previously, know how to reference external image processing libraries, and master the editing logic of image processing applications.

In the case of limited class hours, how to improve teaching efficiency, improve students' absorption of the curriculum and cultivate undergraduates' hands-on practical ability will be a huge challenge for this course. Therefore, we will start with the adjustment of teaching content, the reform of teaching mode and the reform of assessment methods, and cultivate students' ability to work independently in this field based on their interest in employment.

3.1 Construction of Teaching Staff

There are many factors that affect the development of disciplines, among which the most directly related is the quality and stability of teachers. Teachers' academic research background will affect the teaching depth and height of this course. The communication between teachers of this course and teachers of other schools can be increased, which can promote the academic improvement of teachers of this course and guide the teaching of cutting-edge teaching knowledge of this course. Form a teaching team with reasonable age and professional title distribution. Provide opportunities for the growth of young teachers and promote their continuous improvement in teaching; they should guide their direction with future prospects, encourage and praise them in due time, and enhance their sense of teaching achievement and honor. Old teachers with rich teaching experience should communicate more with young teachers, help them solve their difficulties and puzzles in teaching and life in a timely manner, and give them suggestions as people who have come before, so as to increase the sense of belonging of young teachers.

3.2   Adjustment of Teaching Content

In consideration of the characteristics of the major, the teaching content and emphasis have been properly adjusted and expanded. The basic core contents of the course include: basic knowledge of image processing, image transformation, image segmentation, image enhancement and restoration, image compression coding, image description, etc. This part of the content is mainly introduced and guided by heuristic teaching. Students are encouraged to make full use of online teaching resources, consult relevant literature, and master this part of knowledge through self-study. For the parts closely related to scientific research, which are more theoretical and abstract, case teaching and tool based teaching are mainly used; To expand the course content and introduce the content of image recognition, machine vision, visual servo and image tracking closely related to the intelligent manufacturing specialty, so that students can fully understand the internal relationship between image processing technology and the research focus of the specialty, expand their knowledge, and provide a basis for the selection of comprehensive course design at the end of the term.

During the course teaching, students will be divided into study groups. Each course will arrange after-school learning tasks for the group according to needs, and use the knowledge in class to complete specific cases. In the next class, we will arrange class hours for each group to share their learning achievements, explain demonstration cases, and discuss with each other. At the end of the term, we will arrange a comprehensive course design link to enable students to comprehensively use the knowledge learned in the course to solve problems related to identification, vision, tracking, etc.

3.3   Teaching Methods Combined with Digital Twin Technology

At present, the contents of the courses of the intelligent manufacturing specialty are outdated, and the laboratory construction cannot meet the students' practical needs, which causes that the students' practical ability can not be exercised generally, and the teaching objectives of the training project can not be well achieved. It is an important direction to create a virtual experimental environment through digital twin technology to ensure students' participation in practice. This method is beneficial to the realization of online and offline mixed teaching and the expansion of students' learning time and space.

The demand of social development is the direction of future talent training. At the macro level, the digital reform of education depends on the digital transformation of intelligent manufacturing under the new infrastructure. As a key technology to create virtual and real teaching and training scenarios, digital twin technology should be closely combined with curriculum reform, change the old content in the past curriculum system, and integrate new technologies, new processes and new methods into the curriculum, so that students can quickly connect the knowledge they have learned in school with the needs of enterprises, and improve the quality and efficiency of talent training. We use SmartFactoryBuilder (SFB), SFB is a 3D intelligent manufacturing digital design simulation software. Based on the massive element model, the project is quickly built by dragging. The virtual equipment has the same characteristics as the real equipment. The virtual equipment is driven by the actual PLC program, machine tool program,

machine tool NC program, etc., and the debugging and verification of the whole project is completed in the virtual scene. Through the mechanical physics engine, the actual operation effect is achieved.

3.4 Reform of Assessment Methods

The traditional assessment method is to use written examination papers for assessment. This assessment method will mislead students' learning methods and think that this course is a theory oriented course. However, this course is dominated by practical operation. Therefore, only the written examination is not applicable. Only by adopting reasonable assessment methods can the teaching quality be improved, and students' enthusiasm and interest also follow. Therefore, the examination results of this course are mainly composed of three parts: usual results, written examination results and big homework practice results. The usual scores are mainly scored according to the attendance rate, classroom tests and classroom enthusiasm. Students who perform well should be rewarded and advocated. The written test score is mainly the score of the final test paper, the understanding of the most basic concepts and some basic algorithms. The major homework achievement mainly encourages students to start after class to solve practical problems, and mainly trains students' ability of practical operation and analysis and thinking on practical problems. According to the characteristics of the cultivation of applied talents, it is necessary to pay attention to the students' practical ability and the ability to combine theory with practice while giving consideration to the theoretical assessment. The performance evaluation will comprehensively consider the difficulty, frontier, integrity, defense and writing of the topic. The curriculum design that replaces the written examination can better transfer students' energy to the application of knowledge and the completion of projects, which is more in line with the requirements of the ultimate training goal of graduate students.

4   Analysis of the Process of Undergraduate Teaching Practice of "Machine Vision and Application"

We have arranged students' big homework topics, and students can select topics according to their own interests by querying information online. Then, complete the scheme determination, use the experimental platform to verify the code, and write a report. During the class, the students actively discussed the solution to the big homework with the teacher, and the teacher answered the students' questions and understood the progress. After submitting the report, the teacher will give scores according to the completeness and effect of the code. Through extracurricular communication with students, students generally reported that this course has improved their interest in learning, strengthened their ability to apply knowledge, and thus improved their confidence in future work and learning. In addition to the experimental courses and large assignments to cultivate students' practical ability, students should also be encouraged to participate in subject competitions, such as Internet plus, electronic design competitions for college students, and challenge cup competitions, so that students can feel the importance of this course in real life.

Table 2. Achievement degree weight

Course Objectives	Assessment process				
	final exam	experiment	Classroom performance	homework	self-taught
1	50/100	20/100	15/100	10/100	5/100
2	50/100	20/100	15/100	10/100	5/100
3	0	50/100	10/100	20/100	20/100
4	0	50/100	10/100	20/100	20/100

Table 3. Overall goal achievement of the course

Course Objectives	Achievement degree				
	Mean value	standard deviation	Minimum value	Maximum value	Median value
1	0.868	0.136	0.568	0.985	0.864
2	0.857	0.147	0.557	0.964	0.853
3	0.865	0.207	0.584	1.000	0.861
4	0.876	0.203	0.519	0.956	0.872

5 Effect and Evaluation of Teaching Reform

In order to reasonably evaluate the teaching effect and meet the certification requirements of the engineering education specialty, this paper uses the sub item score method to evaluate the reformed machine vision course (to be opened in the second half of 2021), that is, set the weight of each assessment link that supports the goal of this course, calculate the average score of each assessment link, and use the weight calculation.

See Table 2 for the specific weight of each assessment link and Table 3 for the statistics of achievement degree. Take the final average value as the criterion for achieving the curriculum objectives.

It can be seen from Table 3 that the median value of the four curriculum objectives is greater than 0.85, which indicates that the teaching effect after the implementation of the teaching reform is good and the teaching objectives can be achieved better.

6 Experiment Example: Fruit Classification and Recognition

In a computer, an image is described by pixels point by point, and each pixel has a clear position and color value. Use Matlab software to read the image and store the image data in matrix form. The scanning rule is from left to right and top to bottom.

For the convenience of processing a fruit image, we must first convert the color image into a grayscale image. Then the image is binarized to obtain the regional characteristics

of each fruit. Binarization where the fruit touches the background will cause the edge of the image to be broken and frizzy. Therefore, edge extraction is used to make up for the broken edge part, and then the necessary follow-up processing such as removing broken edges and image filling is performed on the image based on the mathematical morphology operator.

After image segmentation, the fruit and the background are clearly distinguished, and then the features of each fruit need to be extracted. The image is labeled first. The so-called image labeling refers to assigning the same label to all the interconnected pixels in the image. After the labeling process, each connected area can be separated, so that their characteristics can be studied.

6.1 Image Binarization Processing

First convert the image to a grayscale image: the function in matlab is named rgb2gray (). Its format: I = rgb2gray (i). That is, the true color image i is transformed into a grayscale image I. Then the grayscale image is binarized: the function in matlab is called im2bw (). The format is: I = im2bw (i, level) where level is the threshold (yu) value, and the value ranges from 0 to 1. This design considers the background color of the picture is white and the brightness is large, so choose level = 0.9 to achieve Binarization.

6.2 Image Segmentation

First of all, before segmentation, open operation and erosion operation are performed on the image to remove noise and smooth the boundary.

(1) Open operation is used to perform morphological open operation on grayscale images, that is, use the same structural elements to perform corrosion operation and then expand operation on the image. The calling format is: I = imopen (i,SE); The open operation can eliminate small noises on the image and smooth the object boundaries.
(2) Corrosion operation is used to eliminate the boundary points of the object. The target shrinks and can eliminate the noise points smaller than the structural element; the function of expansion is to merge all the background points in contact with the object into the object, which is to increase the target and fill the target. Hollow in. The calling format is: I = imerode (i, SE);
(3) Then extract the borders of the fruits in the image to mark each area. The calling format is: I = bwmorph (i,'remove'); the bwmorph function is to perform a specified morphological operation on the image. 'Remove' means that if the 4 neighborhoods of a pixel are all 1, then the pixel will be set to 0; this option will cause the 1 on the boundary pixel to be retained.

6.3 Obtain Features and Discriminant Function

According to the characteristics of the fruit in the image, this paper extracts the features of peach, apple, banana, watermelon, pineapple, pear, etc. in the image from the area feature, quasi-circularity feature, and color (rgb value and hsv value) features. Finally, the

Table 4. The course the fruit characteristic parameters

	pear	*apple*	*peach*	*banana*	*pineapple*
r	0.95	0.8	0.72	1.04	0.55
g	0.81	0.17	0.19	0.85	0.56
b	0.28	0.06	0.13	0.52	0.47
hsv average	0.11	0.20	0.50	0.16	0.26
size	2611	2224	1936	3605	3363
circularity	1.6	1.1	1.08	1.78	1.55

fruits are classified and identified according to the selected features. The characteristic statistics performed as Table 4.

The area of different regions after labeling can be calculated by the number of pixels in the region. Scan the entire image and calculate the area of all connected regions. According to common sense, watermelon has the largest area among the above 6 fruits, followed by pineapple.

6.4   Feature Selection and Final Result Map

The recognition result diagram is as Fig. 1.

In general, the fruits and fruits in this article are well recognized and the recognition is relatively accurate. It's just that the algorithm execution takes a certain amount of time. For brighter and darker images, because this article uses both the hsv model and rgb model to judge, the brightness of the image does not have much influence on the recognition, and the recognition rate is still ideal.
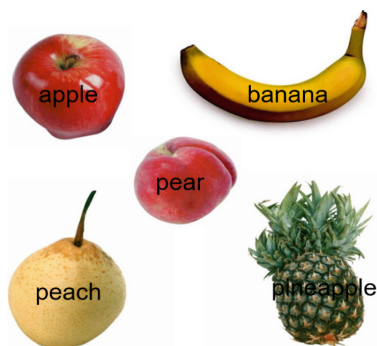
Fig. 1. The result of recognition.

7 Conclusions

The goal of this teaching reform is to improve the application skills of automation majors in local undergraduate colleges in the field of image processing and machine vision, and to build a curriculum system for students in image processing and machine vision. According to the requirements of the certification of the engineering education specialty, the ability of students to transform theory into practice can be cultivated through reasonable selection of course objectives, optimization of teaching content, and strengthening in and out of class training in software and hardware. Adopt diversified assessment methods and evaluate the reformed image processing and machine vision courses based on the sub item score method. The total achievement degree of the program goals exceeded 0.85. Practice shows that reform measures Powerful and effective.

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