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Exploration of Summer Practical Teaching for Artificial Intelligence Engineering Technology Major

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Abstract: Summer practical teaching is crucial for enhancing students' practical skills and fostering an innovative mindset, particularly in vocational undergraduate programs. This paper focuses on the Artificial Intelligence Engineering Technology major at Shenzhen Polytechnic University and outlines the comprehensive teaching plans implemented over four consecutive summer terms. The curriculum is structured into four progressive stages: basic application projects, comprehensive application projects, integrated innovation projects, and cross-border integration projects. The paper further explores the design methodology and implementation process of the summer practical teaching, along with an analysis of its achievements and effectiveness. Central to this curriculum is the Industrial Product Defect Detection System (IPDDS), which captures images of scratches and dirt on bottle caps. By employing advanced artificial intelligence algorithms, the system detects defects and activates audible and visual alarms based on the results. Additionally, it features a robotic arm that sorts defective bottle caps into designated locations. This summer practical teaching initiative exemplifies the concept of product-driven, technology-guided, competence-based, and theory-practice integration. It provides valuable insights and inspiration for practical teaching in vocational undergraduate programs.

1. Introduction

With the increasingly fierce global competition in science and technology, artificial intelligence (AI), as a strategic technology leading the future, has sparked a profound industrial revolution and social transformation worldwide. Governments at both national and local levels have been issuing a series of policies to promote the innovative application and high-quality development of AI [1]. Specifically, China attaches great importance to the development of AI, elevating it to a national strategy through various policy documents, such as the "New Generation Artificial Intelligence Development Plan" issued by the State Council in 2017 [2], the "Guiding Opinions on Accelerating Scene Innovation to Promote High-Level Application of AI for High-Quality Economic Development" jointly issued by six departments, including the Ministry of Science and Technology in 2022 [3], and the "Guangdong Province New Generation Artificial Intelligence Innovation

Development Plan (2022-2025)" released by the Guangdong Provincial Department of Science and Technology and the Department of Industry and Information Technology in 2022 [4], which provide strong policy support and strategic guidance for the innovative application and high-quality development of AI. Additionally, the Guangdong Provincial Government issued the "Implementation Opinions on Accelerating the Construction of an Innovation-Driven AI Industry Hub" in 2023 [5], further detailing the local implementation paths and measures.

Shenzhen, as a frontier of China's reform and opening and a hub of technological innovation, has leveraged its unique geographical location, open policy environment, and strong industrial foundation to become a core region for the national construction of new-generation AI innovation and development pilot zones and national AI innovation application demonstration zones. In 2019, Shenzhen was designated as a National New Generation Artificial Intelligence Innovation Development Pilot Zone [6], and in 2022, it became a National Artificial Intelligence Innovation Application Demonstration Zone [7]. That same year, Shenzhen also introduced the nation's first AI industry-specific legislation [8]. Shenzhen is home to global AI leaders like Huawei, Tencent, and Intellifusion and has formed a complete artificial intelligence industry chain and ecosystem, providing unique conditions for the construction and development of vocational undergraduate majors in Artificial Intelligence Engineering Technology Major.

Summer Practical Teaching, as an essential component of the vocational undergraduate education system, aims to bridge the gap between theory and practice by allowing students to experience and operate in real or simulated work environments. This hands-on approach enhances students' understanding of professional knowledge, improves their ability to solve real-world problems, and fosters innovative thinking and teamwork. Shenzhen Polytechnic University, as a higher education institution with distinctive vocational characteristics, has closely aligned the design of its Summer Practical Teaching in the Artificial Intelligence Engineering Technology Major with the actual needs and development trends of AI industry-education integration [9], actively exploring teaching models and methods that align with the characteristics of vocational undergraduate education.

This paper takes the Artificial Intelligence Engineering Technology Major at Shenzhen Polytechnic University as an example [10], providing a detailed overview of the overall teaching plan across four summer terms. It delves into the design concepts, implementation process, and outcomes of the Summer Practical Teaching in the first year (hereafter referred to as the first summer term). Through a case study analysis, this paper aims to highlight the significant role and value of Summer Practical Teaching in vocational undergraduate education, offering valuable references for other universities in conducting similar practical teaching activities [11]. At the same time, it also discusses how to further optimize the design of Summer Practical Teaching to meet the new requirements for talent cultivation in the AI era, "to contribute wisdom and strength to the sustainable and healthy development of China's AI industry."

2. Holistic Instructional Design

In the context of the new era, higher education, especially vocational and technical education, must closely align with industry development trends, aiming to cultivate highly skilled talents that meet the needs of society [12-13]. The exploration of summer practical teaching in the Artificial Intelligence Engineering Technology Major at Shenzhen Polytechnic University is a concrete practice of this concept. The design philosophy focuses on "product-driven, technology-guided, competence-based, and theory-practice integration" and adheres to a top-level design principle that progresses from foundational to advanced, and from partial to holistic. This approach fully reflects the strategic positioning of Shenzhen and Guangdong as the "manufacturing hub," injecting new vitality into the transformation and upgrading of the local economy.

2.1. First Summer Term: Construction of the Basic Application Project Library

Of particular note is the construction of the basic application project library during the first academic year's summer term, which not only represents an innovative attempt to break away from traditional teaching models but also responds positively to the vision of technology empowerment in traditional industries in the "AI+" era [14]. This project library centers on data analysis and presentation, meticulously designing a cluster of projects that encompass data collection and preprocessing, statistical analysis, front-end design, data visualization (both static and dynamic), and specific applications such as bottle cap defect detection, chip pin defect identification, dimension measurement and positioning, and robotic arm intelligent sorting of defective products. These projects are closely aligned with current mainstream technology frameworks (such as the Echarts chart library, Flask web development framework), and cloud service products (such as ModelArts, EasyDL), aiming to deepen students' understanding and mastery of core course content, such as Python Programming Fundamentals and Applications, Advanced Language Programming, and Introduction to Computer Science, through real or simulated industry application scenarios. The practice of the basic application project library not only strengthens students' professional skills and comprehensive qualities but, more importantly, helps students understand how technology serves the intelligent transformation and upgrading of manufacturing and how it promotes high-quality enterprise development through solving real-world problems. This is a profound implementation of the "integration of industry and education" educational philosophy, as well as an active exploration and contribution to the future talent cultivation model.

2.2. Second Summer Term: Construction of the Comprehensive Application Project Library

In the second academic year, the summer term deepened practical teaching by constructing a comprehensive application project library, expanding learning scenarios from static to dynamic environments. Students develop intelligent agents such as surveillance, security inspection, companion, and smart home systems, reflecting higher technical demands and aligning with trends in intelligent manufacturing and smart living. The project library integrates advanced courses like Machine Learning, Neural Networks, Digital Image Processing, and Linux, enabling students to solve real-world problems and deepen their technical understanding. Advanced platforms, including collaborative and inspection robots, provide industry-relevant practical experience. The project aligns with strategic industries in Shenzhen and nationwide, such as next-generation IT, intelligent manufacturing, and robotics, through partnerships with leading companies like iFlytek, DJI Innovations, and SmartMore. This collaboration enhances industry-education integration, connects the education and talent chains with industry needs, and cultivates innovative, skilled talent. The project library enriches practical teaching, supports vocational education, and fosters local economic growth and industrial upgrading, marking a milestone in AI talent cultivation at Shenzhen Polytechnic University.

2.3. Third Summer Term: Construction of the Integrated Innovation Project Library

In the third academic year's summer term, the Artificial Intelligence Engineering Technology Major establishes an integrated innovation project library focused on intelligent logistics and autonomous driving. This initiative aims to enhance students' abilities in designing and implementing complex systems through interdisciplinary knowledge and innovation. The project library integrates advanced courses like Computer Vision, Natural Language Processing, Intelligent

Robotics, and Speech Signal Processing, enabling students to solve cutting-edge problems. Key projects include designing agricultural product quality evaluation systems, intelligent service robots, translation systems, and autonomous driving systems, challenging students' skills in image processing, hardware integration, and teamwork. Smart cars and autonomous systems serve as product carriers, showcasing innovative results. Collaborations with leading enterprises like iFlytek and UBTECH Robotics expose students to industry trends and real-world projects, accelerating the transformation of knowledge into skills. This initiative fosters innovative thinking, strengthens industry-education integration, and provides a model for advancing vocational undergraduate education in China.

2.4. Fourth Summer Term: Construction of the Cross-disciplinary Integration Project Library

In the fourth academic year's summer term, the Artificial Intelligence Engineering Technology Major builds a project library focused on "AI+X" cross-disciplinary integration, targeting fields like smart healthcare, intelligent transportation, and smart finance. This library integrates core knowledge from four years of study with disciplines such as IT, automation, and AI, creating a comprehensive practical platform. Key projects include intelligent workshop management systems, biometric recognition systems, smart transportation management systems, and 3D digital human systems. These projects emphasize theoretical mastery, practical skills, and problem-solving in real-world scenarios. Advanced AI tools like Huawei and NVIDIA development boards, EasyDL/ModelArts platforms, drones, and GPU servers provide technical support, enabling students to test creative solutions. Students apply knowledge from courses like Computer Vision and Natural Language Processing while fostering teamwork and interdisciplinary collaboration. This initiative enhances students' innovative abilities and prepares them for complex challenges, setting a benchmark for vocational education at Shenzhen Polytechnic University and advancing industry-education integration to produce high-quality technical talent.

3. The Instructional Design for the First Summer Term

3.1. Instructional Implementation Approach

In the first summer term's practical teaching, the teaching team carefully selected a typical application of artificial intelligence technology in the field of intelligent manufacturing—the Industrial Product Defect Detection System (IPDDS) as the teaching case. By focusing on the detection of common defects such as scratches and stains on bottle caps, students not only mastered basic defect recognition skills but were also encouraged to expand their knowledge by attempting to detect more complex defects such as scratches on acrylic plates, broken or bent pins of electronic components, and damaged food packaging, thereby significantly enhancing their ability to solve real-world problems.

The practical teaching content is meticulously planned into two core sections, as shown in Figure 1, aiming to construct a comprehensive learning path from theory to practice.

Figure 1: Teaching Implementation Approach

3.1.1. Theoretical Understanding and Practical Operation

In this phase, teachers guide students to thoroughly explore the operating interface and working principles of the defect detection product. Through a combination of hands-on operational experiences and theoretical explanations, students quickly grasp the basic functions and operational processes of the system. Through simulated operational training in real-world environments, students not only become familiar with various system parameter settings and debugging methods but also gain a deep understanding of the core principles and application value of defect detection technology.

3.1.2. Creative Practice in Manually Building IPDDS

To convert theoretical knowledge into practical skills, the course includes an innovative teaching activity—students manually building the IPDDS. This segment requires students to "disassemble" the product to deeply understand its internal structure and working principles, and encourages them to apply the knowledge they have learned for creative design. Students participate in and lead the entire development process, from requirement analysis, overall design, detailed design, development, debugging, to deployment. This practice allows students not only to consolidate their knowledge but also to develop innovative thinking, teamwork, and problem-solving abilities through hands-on activities. All teaching materials are carefully prepared around the complete product development process to ensure students systematically master each key step, from requirement analysis to product deployment. Through this series of practical activities, students not only gain valuable knowledge and skills but also experience the joy and challenges of innovation, laying a solid foundation for their future careers.

3.2. The Overall Design Plan

This practical project aims to build a complete Industrial Product Defect Detection System (IPDDS) to achieve the collection, processing, labeling, defect detection, and alarm feedback of industrial product images. The system workflow includes: first, image collection of industrial products; then, image preprocessing and labeling to extract valid features; next, advanced artificial intelligence algorithms are applied for defect detection; once a defect is detected, a multi-tiered alarm mechanism of lights, voice, and front-end interface is triggered immediately; finally, the detection results are statistically analyzed and presented to users via a visualized interface.

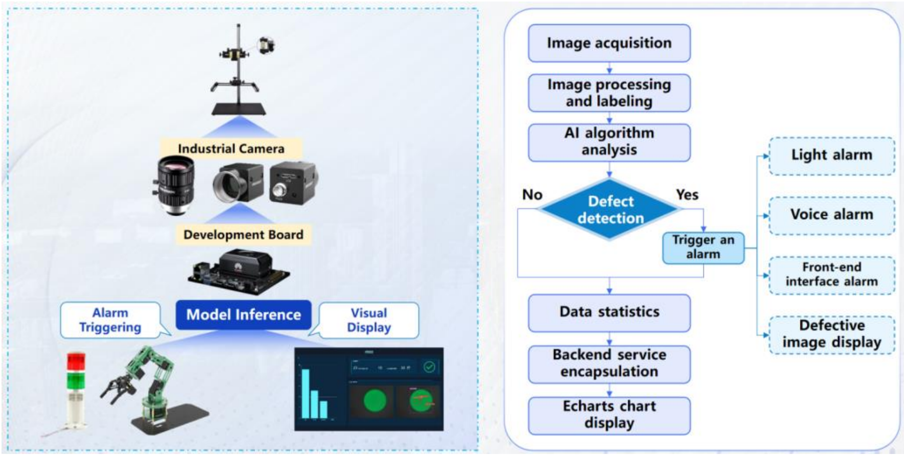

Figure 2: The Overall Design Plan

After determining the overall plan (as shown in Figure 2), the teaching content is broken down into knowledge points, and a detailed implementation plan is designed. According to difficulty, the teaching content is divided into basic and extended tasks, with more challenging tasks such as robotic arm sorting and model optimization being classified as extended tasks. The summer term is scheduled for four weeks before the summer vacation, typically from mid-June to mid-July. A detailed plan is arranged for four weeks of teaching, with the first week being the course introduction and familiarization with defect detection products. Through theoretical explanations, product demonstrations, and hands-on practice, students quickly learn the basic concepts of IPDDS, application scenarios, and the operation of existing products. The second to fourth weeks are dedicated to the manual construction of the IPDDS. Students work in groups, participating in the entire process, from hardware selection and assembly, software interface design, to algorithm implementation and debugging.

3.3. Curriculum Resources and Team Collaboration

Table 1: Curriculum Resources

Resource Type	Resource Name	Quantity	Basic Requirements and Description
Basic Teaching Resources	Teaching Slides	15	Each teaching task must be equipped with at least one teaching slide.
	Teaching Lesson Plans	15	Each teaching task must be equipped with at least one lesson plan.
	Question Bank	30	Each teaching task must include matched questions. The quantity of questions should fully support student learning assessments. Among them, no less than 20% should include open-ended/non-standard answer questions, case studies, and comprehensive application problems. Each question must have answers and explanations.
	Practice Instruction Documents	12	Modules should be set up according to the project production process, with a total of 4 modules.
	Project Material Resources	200	Samples for realistic industrial visual defect detection.
Expanded Teaching Resources	Competition Tasks	2 sets	Classroom competitions based on practical corporate projects.
	Case Database	5	Real corporate project cases.

The first summer term includes different curriculum resources, as shown in Table 1.

Teaching Staff Allocation: The software, hardware, and algorithm development of IPDDS are each led by a teacher with extensive experience, ensuring the quality and efficiency of the teaching.

Testing and Joint Debugging: After passing unit tests, detailed interface documentation is prepared, followed by integration testing and system debugging to ensure seamless connection between modules and stable system operation.

Deployment and Performance Evaluation: Upon completing all development work, the software and hardware systems are deployed, and comprehensive performance testing, including detection accuracy and alarm response time, is conducted to ensure the system meets actual needs.

4. Teaching Implementation

The first summer-term practical course is a project-based design course, as shown in Figure 3.

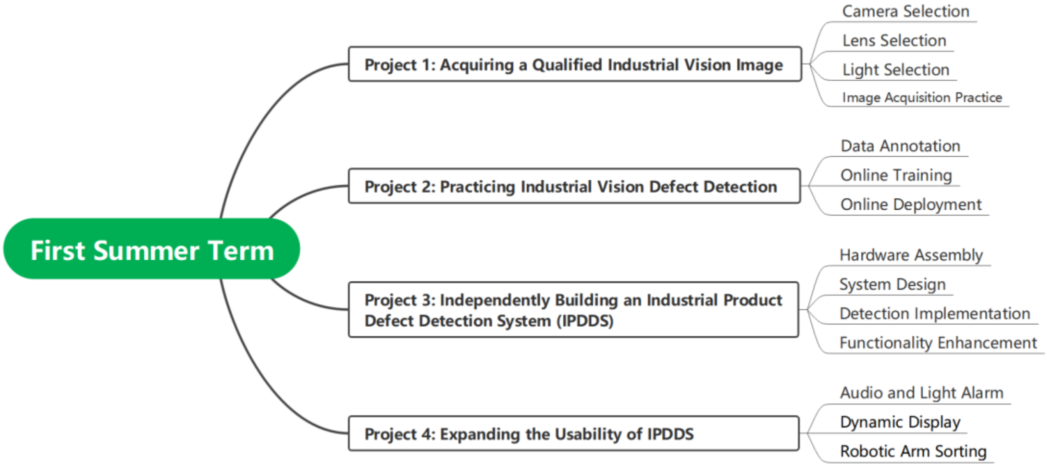

Figure 3: Project-Based Design Course

During the implementation of the summer term's teaching activities, the teaching team meticulously designed a series of practical exercises, including hardware assembly, data collection, data processing, data annotation, model training, model deployment, visualization, audio and light alarm, and robotic arm sorting, with the aim of comprehensively enhancing students' practical skills and innovative thinking. The process is illustrated in Figure 4.

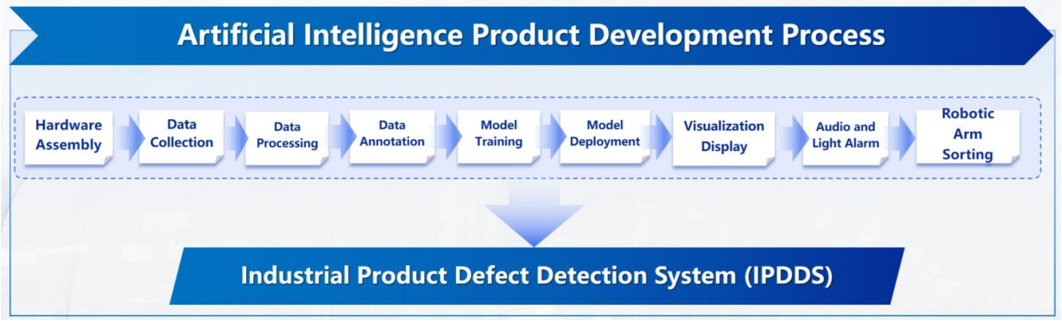

Figure 4: Teaching Implementation Process

Hardware Assembly: Students assembled hardware like frames, cameras, lenses, development boards, alarms, and robotic arms using detailed manuals. This enhanced hands-on skills and deepened their understanding of component functions and interactions.

Data Collection & Preprocessing: Lacking real-world defect samples, students manually created diverse datasets, collected high-quality industrial images, and applied preprocessing techniques (enhancement, filtering, cleaning). Online/offline annotation ensured dataset accuracy and efficiency.

Model Training & Deployment: Using annotated datasets and GPU servers, students trained deep learning models for defect detection, achieving accurate classification. Models were deployed on Huawei/NVIDIA boards for efficient operation.

Results Visualization & Sorting: Defect detection results were visualized using Echarts, while alarms and robotic arms automated sorting. For example, red lights and rapid beeping indicated dirty caps, yellow lights and slow beeping flagged scratches, and green lights signified no defects.

Expert Guidance: Teachers and industry engineers collaborated on challenges, with experts providing on-site guidance and professional insights, enhancing students' skills and knowledge absorption.

Knowledge Integration: Students applied cross-disciplinary knowledge (e.g., optics, networking, Python, machine learning) in every stage, reinforcing prior studies and laying a foundation for future learning while promoting skill development.

5. Conclusions

To conclude, after an in-depth analysis of the typical applications of artificial intelligence technology in the field of smart manufacturing, particularly in industrial product defect detection systems, the design of this summer term practical teaching not only successfully showcased a unique educational model that integrates industry and education, product embodiment, technology-driven, competency-based, and integration of theory and practice but also provided valuable experiences and insights for practical teaching exploration in the vocational undergraduate education sector. In light of the achievements and shortcomings of this teaching practice, future plans should be further refined and optimized to achieve higher educational effectiveness and social application value, such as:

(1) Building an Integrated "Edge-Cloud" AI Practical Teaching System: Construct a comprehensive teaching system for dynamic defect intelligent detection across terminal data collection, edge computing, and cloud-based analysis.

(2) Continuous Optimization of the Curriculum System and Talent Training Plan: Reverse-engineer the curriculum system for tighter connections and clearer logic, integrating interdisciplinary modules for knowledge fusion.

(3) Pre-Teaching of Key Knowledge and Skills: Pre-teach foundational knowledge and skills in prerequisite courses to prepare students for the summer term project.

(4) Deepening School-Enterprise Cooperation to Solve Industry Problems: Strengthen cooperation with enterprises for direct project connections to production lines, facilitating research-to-production transformations.

(5) Building and Promoting a National Skills Competition System for Teachers and Students: Collaborate on a national skills competition framework to enhance student innovation, teacher practical teaching abilities, and inter-school exchanges.

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