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Curriculum System Reform & Practice for Image Processing under Cloud Computing Platform

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Abstract: *With the in-depth development of a new round of technological revolution and industrial transformation, "New Engineering Education" has become a core topic in higher engineering education reform. Cloud computing and image information processing, as key components of emerging technology fields, have become important drivers for intelligent upgrading of related industries through their deep integration. This paper discusses the necessity and urgency of curriculum system reform that integrates cloud computing and image information processing in the context of new engineering education. It analyzes the challenges faced by traditional curriculum systems and proposes a curriculum reform approach based on "platform-led, module integration, project-driven, and industry-education collaboration." The paper elaborates on the core content of integrated courses, practical component design, and supporting teaching methods and evaluation mechanisms. Through specific implementation cases, it validates the positive role of this curriculum system in enhancing students' innovation capabilities, engineering practice abilities, and adaptability to industry development needs, providing valuable reference for talent cultivation model reform in new engineering-related majors.*

Keywords: *Cloud Computing; Image Processing; Curriculum System Reform; Practical Teaching*

1. Introduction

With the rapid development of artificial intelligence, big data, and Internet of Things technologies, cloud computing and image information processing have become important driving forces for industrial upgrading. New engineering education requires universities to break traditional disciplinary barriers and construct cross-disciplinary curriculum systems oriented toward complex engineering problems[1]. However, most universities currently face the following issues in cloud computing and image processing course teaching[2-4]:Outdated course content: Failure to promptly reflect the latest technological developments in cloud computing platforms (such as Huawei Cloud, AWS) and image processing frameworks (such as OpenCV, TensorFlow); Weak practical teaching: Lack of project-based teaching resources based on real industrial scenarios, resulting in insufficient hands-on abilities among students; Insufficient university-enterprise collaboration: Disconnect between course design and enterprise requirements, making it difficult for students to adapt to actual industry needs[5]. Cloud computing provides new technical support for image information processing: Elastic computing power expansion: Dynamic allocation of GPU cluster resources through private cloud platforms like OpenStack or public cloud services, supporting compute-intensive experiments such as deep learning image segmentation; Distributed data processing[6]: Using Hadoop Distributed File System to store terabyte-level image datasets, combined with MapReduce framework for parallel image processing; Standardized environment deployment[7]: Encapsulating image processing environments such as OpenCV and TensorFlow using Docker container technology, resolving dependency conflicts and improving experiment reproducibility efficiency.

The advantages of integration between the two fields are manifested as: cloud computing provides powerful computing and storage resources for image information processing, solving bottlenecks in massive image data processing; image information processing technology provides rich visual perception and analysis capabilities for cloud computing applications, expanding cloud computing service scenarios. This integration has broad application prospects in smart cities, intelligent manufacturing, medical imaging, autonomous driving, and other fields.

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2. Integrated Curriculum System Reform Approach

Following the principles of "student-centered, outcome-oriented, and continuous improvement," the goal is to cultivate high-quality compound engineering technical talents that meet the needs of the new era's industries. The approach emphasizes equal importance of theory and practice, knowledge transfer and ability cultivation, and campus teaching and industry requirements.

2.1 "Platform-led, Module Integration, Project-driven, Industry-Education Collaboration"

(1) Construct an integrated practical platform for cloud computing and image information processing that combines teaching, experimentation, and project development.

(2) Break down existing course barriers, organically integrate core knowledge points of cloud computing and image information processing, and form serialized integrated course modules.

(3) Use real enterprise projects or cutting-edge research topics as drivers throughout the course teaching process to stimulate students' learning interest and initiative.

(4) Actively introduce enterprise resources to jointly build courses, compile textbooks, establish practical bases, and guide students together, achieving effective connection between education chain, talent chain, industry chain, and innovation chain.

2.2 Specific Reform Objectives

(1) Knowledge objectives: Enable students to systematically master the basic theories, core technologies, and integrated application methods of cloud computing and image information processing.

(2) Ability objectives: Cultivate students' capabilities in image data processing, analysis, application system design and development in cloud environments, as well as their abilities to solve complex engineering problems and innovate and start businesses.

(3) Quality objectives: Enhance students' team collaboration spirit, engineering ethics, lifelong learning awareness, and international perspective.

3. Integrated Curriculum System Design

3.1 Overall Framework of the Curriculum System

The knowledge system architecture of the integrated curriculum system includes four levels (Fig.1):(1)Foundation theory layer: Includes mathematical foundations, computer science foundations, signal and system foundations, and other supporting knowledge, providing theoretical foundations for cloud computing and image processing. (2) Professional core layer: Includes core knowledge of cloud computing (such as distributed systems, virtualization technology, cloud service models) and core knowledge of image processing (such as image acquisition and representation, image enhancement and restoration, image analysis and recognition). (3) Integration application layer: Focuses on integration points between cloud computing and image processing, such as cloud platform-based image processing system design, distributed image processing algorithms, and cloud-based image service development. (4) Innovation practice layer: Designs comprehensive projects and innovative practical activities oriented toward actual application scenarios, cultivating students' engineering practice abilities and innovation capabilities.

3.2 Core Integrated Course Content Explanation

Taking "Cloud-based Image Analysis and Recognition" as an example, its teaching content is detailed as follows:

(1) Cloud platform basics: Introduction to image processing-related services on mainstream public cloud platforms (such as AWS, Azure, Alibaba Cloud, Huawei Cloud), including object storage, GPU cloud servers, AI platform services, etc.

(2) Development environment setup: Configuring deep learning development environments in the cloud, using tools like Jupyter Notebook for interactive development.

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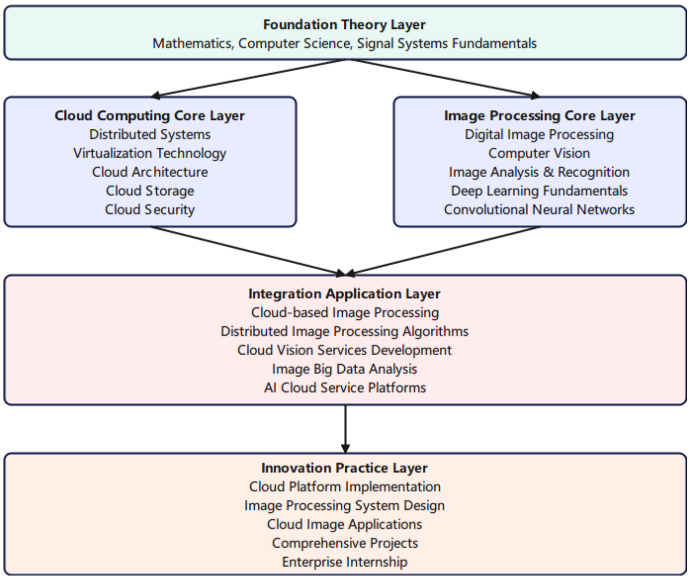

Fig.1 Curriculum Framework for the Integration of Cloud Computing and Image Information Processing

(3) Data preparation and preprocessing: Methods for annotation, enhancement, and cleaning of massive image data in the cloud.

(4) Model training and optimization: Distributed training principles, how to accelerate model training using multi-GPU resources in the cloud, and hyperparameter tuning techniques.

(5) Model deployment and inference: Deploying trained models as cloud services (API form), implementing online inference for image analysis and recognition, and model lightweight and acceleration technologies.

(6) Case studies: Project practice combining specific application scenarios (such as face recognition, vehicle detection, medical image-assisted diagnosis, etc.).

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3.3 Practical Component Design

(1) Basic experiments: Verification and design experiments targeting core technical points, such as cloud server setup and configuration, object storage usage, and basic image processing algorithm implementation in the cloud.

(2) Course design: Requiring students to comprehensively apply learned knowledge to complete a small-scale image information processing cloud service system design with a clear application background, such as "Cloud-based Album Intelligent Classification System" or "Cloud-based Traffic Flow Monitoring System."

(3) Enterprise-level project training: Introducing real enterprise projects, allowing students to participate in the entire process of requirement analysis, solution design, code implementation, and testing deployment under the joint guidance of enterprise mentors and school instructors.

(4) Open laboratory and innovation platform: Building a dedicated "Cloud Computing and Image Information Processing Integration Innovation Laboratory," providing necessary hardware and software resources and technical support, encouraging students to independently conduct innovative experiments and research projects.

4. Results

4.1 Teaching Methods and Evaluation Mechanism Reform

4.1.1 Cloud Platform-based Blended Teaching Model

To adapt to the talent cultivation requirements of new engineering education, this curriculum system

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adopts a cloud platform-based blended teaching model (Fig.2):

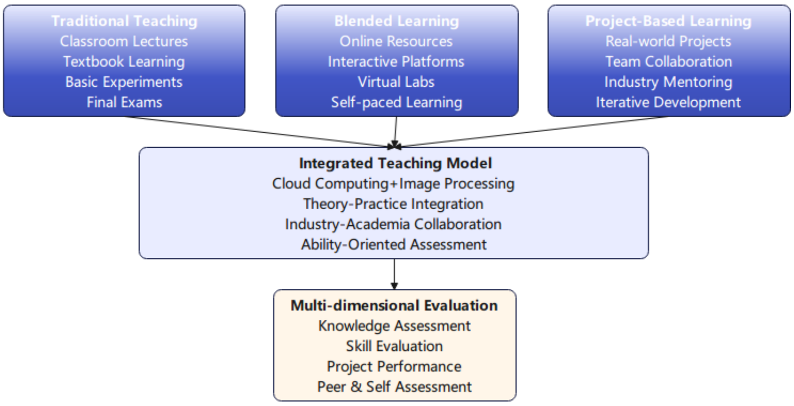

Fig.2 Hybrid teaching model based on cloud platform

(1) Online and offline blended teaching: Utilizing cloud platforms to build online learning environments, providing course resources, online experiments, and interactive discussions, organically combined with offline classroom teaching to optimize teaching resource allocation.

(2) Theory-practice integrated teaching: Breaking the boundaries between theoretical and experimental courses, adopting an integrated "lecture-practice-do" teaching model, interspersing practical operations during theoretical instruction to strengthen the combination of theory and practice.

(3) Project-driven teaching: Using real projects as carriers, guiding students to learn knowledge and cultivate abilities during project implementation, achieving a transition from "learning by doing" to "doing while learning."

(4) Team collaborative learning: Organizing student teams to collaboratively complete projects, cultivating team cooperation spirit and communication coordination abilities, while ensuring each student masters comprehensive knowledge and skills through role rotation.

(5) Flipped classroom teaching: Students master basic knowledge through online learning, while classroom time is used for problem discussion, case analysis, and project guidance, improving classroom teaching efficiency.

4.1.2 Project-driven Practical Teaching Methods

Practical teaching is an important component of this curriculum system, adopting project-driven practical teaching methods:

(1) Progressive project design: Designing projects at different levels following the progressive path of "basic experiments-comprehensive experiments-course projects-comprehensive projects," gradually increasing difficulty and comprehensiveness.

(2) Real scenario introduction: Introducing real enterprise projects and cases, creating learning environments close to actual work, improving students' learning interest and practical abilities.

(3) Open-ended project tasks: Designing open-ended project tasks, encouraging students to explore independently and design innovatively, cultivating innovative thinking and problem-solving abilities.

(4) Agile development methods: Introducing agile development concepts and methods, cultivating students' engineering practice abilities through iterative development, continuous integration, and frequent feedback.

(5) Achievement display and exchange: Organizing project achievement displays and exchange activities, encouraging students to share experiences and learn from each other, enhancing expression abilities and self-confidence.

4.1.3 Diversified Learning Evaluation System

To comprehensively evaluate students' learning outcomes, a diversified learning evaluation system is constructed (Fig.3):

(1) Combination of process and outcome evaluation: Emphasizing evaluation of the learning process, including classroom performance, assignment completion, experiment reports, and project progress,

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while also focusing on evaluation of final learning outcomes.

(2) Comprehensive evaluation of knowledge, abilities, and qualities: Evaluation content includes knowledge mastery level, professional skill level, innovation ability, team collaboration ability, and professional quality across multiple dimensions.

(3) Combination of self-evaluation, peer evaluation, and teacher evaluation: Introducing a combination of student self-evaluation, peer evaluation, and teacher evaluation to form multi-angle, all-round evaluation.

(4) Combination of qualitative and quantitative evaluation: Establishing a scientific evaluation indicator system, organically combining qualitative and quantitative evaluation to improve the objectivity and scientific nature of evaluation.

(5) Combination of formative and summative evaluation: Conducting formative evaluation during the teaching process to promptly identify problems and adjust teaching strategies, and conducting summative evaluation at the end of the course to comprehensively evaluate learning outcomes.

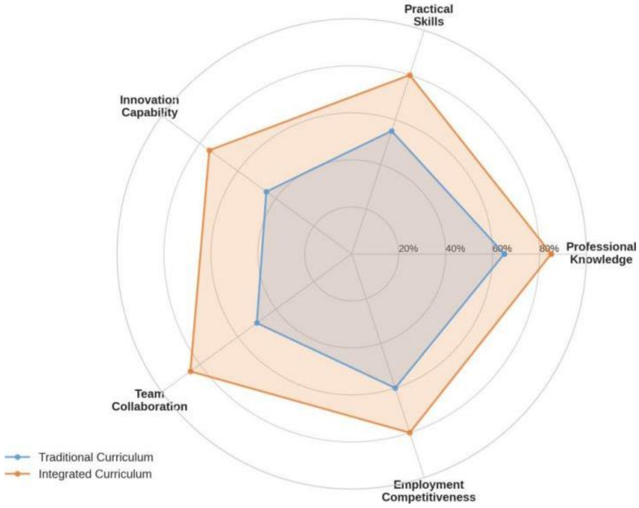

Fig.3 Comprehensive Project Practice Oriented to Practical Applications

4.2 Typical Course Implementation Cases

4.2.1 Cloud Platform-based Image Processing Foundation Course

Course Overview: This course is a professional foundation course for second-year undergraduate students, aiming to cultivate students' basic image processing theory and practical abilities in cloud environments. The course consists of 48 class hours, including 32 hours of theoretical teaching and 16 hours of practical teaching[8].

Teaching Objectives: Through this course, students should master the basic concepts and representation methods of digital images, understand basic algorithms such as image enhancement, restoration, and segmentation, be able to use cloud platforms for image processing experiments, and initially possess the ability to develop simple image processing applications in cloud environments.

Course Content: The course content is divided into four modules: image basics (image acquisition, representation, and transformation); basic image processing methods (enhancement, restoration, segmentation); cloud computing basics (virtualization, resource management, service models); and image processing in cloud environments (distributed storage, parallel processing).

Teaching Methods: The course adopts an "online + offline" blended teaching model. Online, the MOOC platform provides video explanations, online tests, and discussion exchanges; offline, the classroom adopts a flipped classroom approach, focusing on case analysis, problem discussion, and project guidance. Practical teaching adopts a project-driven method, designing small projects such as "Cloud-based Image Filter Application" to guide students in mastering knowledge and skills through practice.

Evaluation Methods: Course evaluation adopts a diversified approach, including: online learning situation (20%), classroom performance (10%), experiment reports (30%), and project outcomes (40%).

ISSN 2522-6398 Vol. 8, Issue 6: 25-32, DOI: 10.25236/FER.2025.080604

Particularly in the project evaluation section, attention is paid not only to final outcomes but also to development processes, document quality, and team collaboration.

Implementation Effects: Over the two years of course implementation, students' learning enthusiasm and practical abilities have significantly improved. Through questionnaire surveys, 92% of students believe that the blended teaching model effectively improved learning efficiency, and 88% of students indicated that project-driven practical teaching enhanced learning interest and hands-on abilities. The quality of student works has improved year by year, with some excellent works winning awards in school-level innovation competitions.

4.2.2 Image Analysis and Recognition Course in Cloud Computing Environment

Course Overview: This course is a professional core course for third-year undergraduate students, aiming to cultivate students' abilities in advanced image analysis and recognition in cloud computing environments. The course consists of 64 class hours, including 40 hours of theoretical teaching and 24 hours of practical teaching.

Teaching Objectives: Through this course, students should master the basic theories and methods of image feature extraction, pattern recognition, and deep learning, understand the principles and technologies of distributed image processing in cloud computing environments, and be able to design and implement cloud platform-based image analysis and recognition systems.

Course Content: The course content is divided into five modules: image feature extraction (color, texture, shape features); traditional image recognition methods (statistical pattern recognition, support vector machines, etc.); deep learning basics (CNN, RNN, etc.); cloud computing architecture (IaaS, PaaS, SaaS models); and distributed image processing (image processing under MapReduce and Spark frameworks).

Teaching Methods: The course adopts a "theory + practice + project" three-in-one teaching model. Theoretical teaching focuses on concept explanation and case analysis; practical teaching designs eight experiments, from basic image feature extraction to complex deep learning model training; project teaching requires student teams to complete the design and implementation of a "Cloud-based Intelligent Image Classification System," comprehensively applying theoretical knowledge and practical skills.

The course introduces a "sandbox experiment" mode, allocating independent cloud resource quotas for each student team, allowing students to independently create virtual machines, deploy containers, and manage storage resources, conducting experiments and project development in real cloud environments.

Evaluation Methods: Course evaluation adopts a comprehensive evaluation approach of "process + outcome + ability," including: theoretical assessment (30%), experiment reports (20%), project development (40%), and team collaboration (10%). Project evaluation adopts a "teacher-student mutual evaluation + enterprise expert review" approach, evaluating from multiple dimensions such as technical implementation, innovation, practical value, and document quality.

Implementation Effects: Over the three years of course implementation, students' professional abilities and innovation awareness have significantly improved. Multiple projects developed by student teams have achieved good results in practical applications, such as the "Campus Intelligent Monitoring System" already being tested in campus security, and the "Medical Image-assisted Diagnosis System" receiving support from university-enterprise cooperation innovation projects. Graduates with combined backgrounds in cloud computing and image processing are favored by enterprises in employment interviews, with employment quality significantly improved.

Project Overview: This project is a comprehensive practical course for fourth-year undergraduate students, adopting a real project-driven approach to cultivate students' abilities to solve complex engineering problems. The project lasts for one semester (16 weeks) and is jointly guided by university-enterprise cooperation.

Project Background: The project originates from cooperation with a smart city solution provider, requiring student teams to design and implement a "Cloud Platform-based Urban Traffic Image Analysis System." The system needs to process video streams from various traffic intersections in the city, analyze traffic conditions in real-time, identify vehicle types and flow, predict traffic congestion, and provide visualization and decision support.

Project Objectives: Through project practice, students should be able to: understand complex system requirement analysis and architecture design methods; master distributed image processing technologies under cloud platforms; be able to apply deep learning methods for video analysis and object recognition;

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possess team collaboration and project management abilities; and develop engineering document writing and technical communication abilities.

Project Implementation: The project adopts agile development methods, divided into four iteration cycles, each including five phases: requirement analysis, design, coding, testing, and review. Students are divided into teams of 5-7 people, with each team responsible for a module of the system, such as video collection module, image preprocessing module, object detection module, data analysis module, and visualization display module.

Project guidance adopts a "dual mentor system," with school teachers responsible for technical guidance and process management, and enterprise mentors providing requirement guidance and technical consultation. A project meeting is held once a week to report progress, solve problems, and adjust plans.

Technical Route: The system adopts a microservice architecture, deploying various functional modules based on Kubernetes; using Kafka to implement real-time transmission of video streams; adopting the YOLO algorithm for vehicle detection and classification; using Spark Streaming for stream data processing and analysis; implementing data storage and retrieval based on the ELK stack; and developing front-end visualization interfaces using Vue.js and ECharts.

Evaluation Methods: Project evaluation adopts a multi-dimensional evaluation approach, including: technical implementation (40%), system performance (20%), document quality (15%), team collaboration (15%), and defense performance (10%).

Evaluation subjects include school teachers, enterprise mentors, and student representatives, forming comprehensive and objective evaluation results.

Implementation Effects: Over the two years of project implementation, student teams have developed a total of eight systems, three of which have been actually deployed and applied with enterprise support. Through project practice, students have not only consolidated professional knowledge but also cultivated engineering practice abilities and innovation awareness. Enterprise feedback indicates that students who participated in the projects performed outstandingly in practical work abilities, team collaboration, and technical innovation, adapting to work requirements faster than students from traditional cultivation models.

5. Results

In the context of new engineering education, this paper systematically studied the curriculum system reform and practice issues of cloud computing and image information processing integration. The main research achievements include:

(1) Analyzed the theoretical foundations and practical needs of cloud computing and image information processing integration in the context of new engineering education, clarifying the deep integration trends of the two fields at the technical level and the urgent needs of talent cultivation, providing theoretical basis for curriculum system reform.

(2) Constructed an innovative curriculum system framework for cloud computing and image information processing integration, including knowledge system architecture, course module division, core course design, and teaching method evaluation system, forming a complete curriculum system solution.

(3) Designed a cloud platform-based blended teaching model and project-driven practical teaching methods, innovating teaching implementation paths, improving teaching effects and student participation.

(4) Verified the feasibility and effectiveness of the integrated curriculum system through typical course implementation cases and teaching effect evaluation, providing practical reference for similar professional course reforms.

With the rapid development of new-generation information technology and the in-depth advancement of industrial transformation, the curriculum system for cloud computing and image information processing integration still needs continuous improvement and development. Future research directions mainly include:

(1) Integration of cutting-edge technology: Continuously paying attention to the latest developments in cloud computing, artificial intelligence, and image processing technologies, promptly integrating frontier technologies such as edge computing, federated learning, and generative AI into course content.

ISSN 2522-6398 Vol. 8, Issue 6: 25-32, DOI: 10.25236/FER.2025.080604

(2) Teaching model innovation: Exploring the application of new technologies such as virtual reality and augmented reality in teaching, innovating teaching methods and learning approaches, enhancing learning experiences and teaching effects.

(3) International perspective expansion: Strengthening international cooperation and exchange, introducing internationally advanced educational concepts and teaching resources, enhancing the internationalization level of courses, and cultivating talents with international competitiveness.

(4) Deep integration of innovation and entrepreneurship: Deeply integrating innovation and entrepreneurship education into the curriculum system, supporting students in transforming course projects into entrepreneurial projects, and cultivating innovation and entrepreneurship abilities.

(5) Intelligent evaluation system: Using big data and artificial intelligence technologies to construct an intelligent learning evaluation system, achieving precise evaluation and personalized feedback on learning processes and outcomes.

(6) Construction of industry-education integration ecosystem: Constructing an industry-education integration ecosystem, forming a talent cultivation mechanism with multi-party collaboration among schools, enterprises, industries, and government, achieving resource sharing and complementary advantages.

Through continuous research and practice, we believe that the curriculum system for cloud computing and image information processing integration will continuously improve and develop, providing strong support for cultivating high-level engineering and technology talents adapted to the needs of new economic development, and making positive contributions to promoting industrial innovation development and digital economy construction.

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