

Research on the Continuous Improvement Mechanism of *Digital Image Processing* Course Quality Empowered by Artificial Intelligence

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Abstract: Aiming at the prevalent pain points in the teaching of the *Digital Image Processing* course for communication engineering majors, such as a fragmented knowledge system, differentiated student foundations, and disconnected practical application, this study implements an artificial intelligence (AI)-driven educational model at Suqian University. The three-stage framework—"Foundation Building, Scenario Delving, and Intelligent Leap"—combines AI-powered modular knowledge mapping, dynamic tiered instruction, project-based learning (PBL) integration, AI-adaptive platforms, and industry-academia collaboration. These innovations effectively resolve traditional teaching bottlenecks. Practical implementation demonstrates significant improvements in student engagement, practical skills, and innovative thinking. Notable outcomes include increased competition awards, heightened research participation, and improved course satisfaction. The reform model has been successfully replicated across the "AI + Communication" curriculum cluster, establishing a replicable paradigm for engineering education innovation.

Keywords: Digital Image Processing; Teaching Reform; Artificial Intelligence; Hierarchical Teaching

1. Introduction

With the rapid development of artificial intelligence, big data, and 5G/6G communication technologies, image, as an important carrier of information, its processing technology has become one of the core competencies in fields such as communication engineering, electronic information, and computer science[1-4]. As a key professional

course for communication engineering majors, the *Digital Image Processing* course undertakes the responsibility of cultivating students' mastery of the basic principles, core algorithms, and engineering application capabilities of image processing. However, the traditional teaching model faces severe challenges in the teaching of this course.

1.1 Fragmented Knowledge System

The course covers more than ten modules including image enhancement, segmentation, compression, and restoration. The content is extensive and highly interconnected. Traditional linear teaching tends to result in the accumulation of knowledge points, making it difficult for students to establish a systematic understanding and leading to vague learning objectives. For instance, when the derivation of Fourier transform formulas is taught in isolation, students struggle to understand its practical value in image denoising and feature extraction.

1.2 Differentiated Student Foundations

There are significant differences among communication engineering students in terms of programming abilities (e.g., Matlab/Python) and mathematical foundations (e.g., linear algebra, probability and statistics). The traditional "one-size-fits-all" teaching approach fails to meet the needs of students at different levels. Students with weak foundations tend to fall behind, while those with strong foundations lack room for advanced learning. For example, in the chapter on image compression, some students need to start with the principles of JPEG, while others already have the foundation to explore deep learning-based compression methods.

1.3 Disconnected Practical Application

The course involves a large number of

mathematical derivations (e.g., convolution, wavelet transform) and interdisciplinary knowledge (e.g., signal processing, computer vision). Students generally tend to "focus on code implementation while neglecting principle understanding". Traditional verification-based experiments cannot effectively connect algorithm principles with actual engineering scenarios, leading to a disconnect between theory and practice. As a result, students find it difficult to apply what they have learned to meet industrial demands[5]. For example, experiments on histogram equalization often remain at the level of code debugging, lacking in-depth thinking about its applicability in scenarios such as low-light image enhancement. To address the above pain points, the teaching team of the *Digital Image Processing* course for the Communication Engineering major at Suqian University has carried out a series of explorations and practices on teaching improvement mechanisms, with AI technology deeply empowering the entire teaching process[6-8].

2. Innovative Concepts and Ideas

In the course improvement process, with AI technology as the cornerstone, the teaching team has established clear course objectives around the three dimensions of knowledge, competence, and quality, in line with the 12 competence requirements for emerging engineering education.

2.1 Knowledge Objectives

Construct a dual-driven knowledge system of "traditional image processing technology + modern AI technology"[9]. Students are required to master traditional core technologies such as spatial/frequency domain enhancement, image restoration, segmentation, compression coding, and color image processing; at the same time, they should understand the application principles of AI models (e.g., CNN, U-Net, YOLO, GAN) in tasks such as image classification, segmentation, detection, restoration, and super-resolution.

2.2 Competence Objectives

Cultivate students' abilities to solve complex engineering problems using image processing and AI technologies, as well as their innovative practical abilities, teamwork abilities, and lifelong learning abilities. Emphasis is placed

on enhancing students' ability to apply image processing technologies in communication scenarios (e.g., video compression transmission, image-enhanced communication).

2.3 Quality Objectives

Cultivate students' engineering ethics, social responsibility, and innovative spirit. Through the integration of ideological and political education in the curriculum (e.g., using AI technology for the digital protection of cultural heritage), students' passion for serving the country through science and technology is strengthened.

Based on emerging engineering education, the course adheres to the student-centered educational philosophy and the intelligent teaching concept. It summarizes and analyzes practical teaching problems, takes AI as the driver and penetration force to promote the in-depth integration of AI technology and course content, and implements the "Foundation Building - Scenario Deepening - Intelligent Leapfrogging" three-stage new talent cultivation model. Continuous improvements are made to teaching innovation measures to effectively solve course teaching problems.

3. Reform Measures

In today's world swept by the wave of digital technology innovation, the *Digital Image Processing* course, as a core link between AI and computer science fields, is facing an unprecedented transformation in teaching paradigms[10-12]. With "AI + Classroom" as the link, intelligent hierarchical teaching as the engine, and the cutting-edge application of AI algorithms in the field of digital image processing as the key breakthrough point, this course integrates innovative elements such as "technological frontiers, innovative thinking, and competition achievements". In terms of course content, modular cases are constructed by modularizing in-class theoretical knowledge; inquiry-based cases are built through extracurricular group discussion and inquiry; and challenging cases are developed by projectizing scientific research and competition achievements. These cases are then developed into digital course resources, forming a competence closed loop of "principle understanding - algorithm optimization - industrial application", and truly transforming textbook knowledge into a driving force for

industrial innovation.

3.1 Foundation Building

3.1.1 Modular thematic teaching

The course content is reorganized into four modules: "Image Foundation - Core Algorithms - AI Migration - Industrial Application"[13]. Theoretical knowledge is connected through real cases, and the core algorithms of each

chapter are sorted out. Combined with cutting-edge industrial application scenarios of AI, 9 application units are set up to help students establish a connection between the image processing knowledge system and practical applications. The modular teaching structure diagram after the course reconstruction is shown in Figure 1.

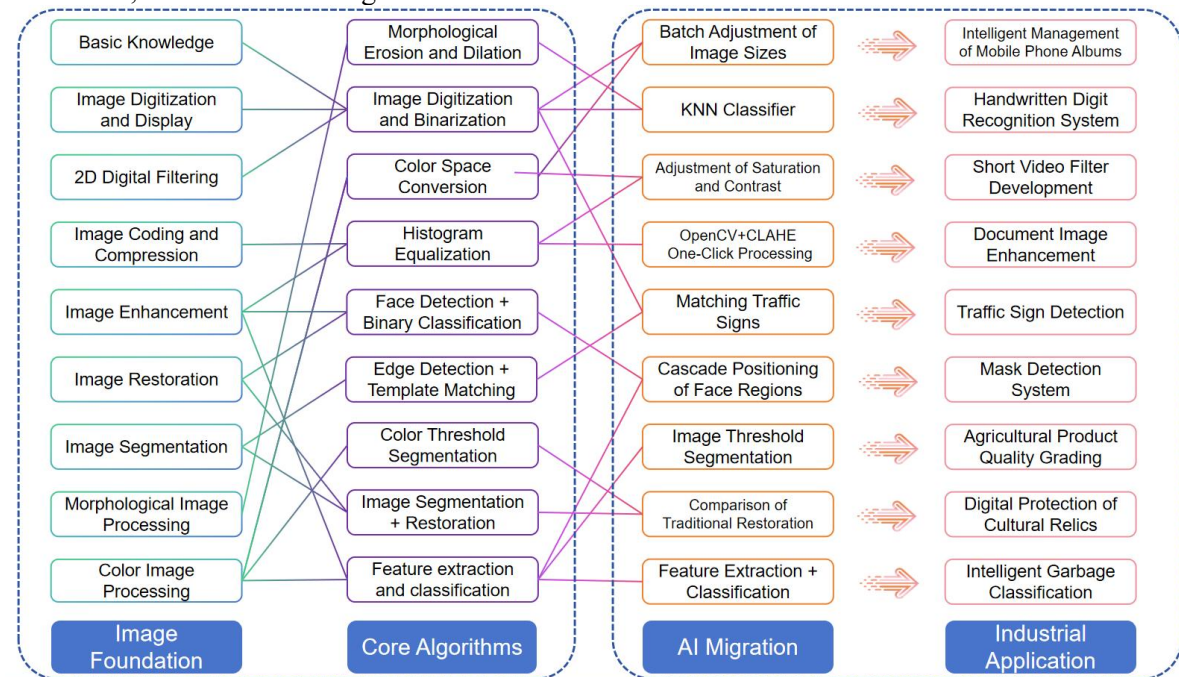


Figure 1. Modular Teaching Structure Diagram after Course Reconstruction

3.1.2 AI knowledge graph navigation to enhance students' learning enthusiasm

A dynamic knowledge graph is constructed. Through AI algorithms, more than 200 core knowledge points are automatically associated with over 30 industrial application scenarios. Isolated modules such as filter design and image transformation are woven into a dynamically expandable knowledge network. AI algorithms are used to automatically associate modules such as image transformation, noise reduction, and feature extraction, and a personalized learning path is generated through an intelligent recommendation system. This transforms knowledge from statically stored "bricks" into an interactive and growing "neural network". At the same time, through the statistical details of knowledge points, the learning situation of each student can be fully grasped, facilitating individualized teaching according to different students' learning conditions.

3.1.3 Project-based learning (PBL)

The course adopts the PBL (Project-Based

Learning) teaching method. The course is carried out around specific projects related to the digital image processing industry. Teachers, as guides, help students experience exploration in the process of project implementation, enabling them to "learn by doing and do by learning" and stimulating their learning interest. The projects set in the course require students to use image processing and AI technologies to complete comprehensive projects such as "deep learning-based license plate recognition system", "deep learning-based pest identification system", "intelligent garbage classification and recognition system", and "digital protection of cultural relics" in groups. Through group discussions and group leaders' project presentations, students' teamwork awareness is encouraged and their classroom participation is improved.

3.2 Scenario Deepening

3.2.1 Dynamic grouping and flexible tasks

Students are divided into four levels (Top Excellence Level, Academic Excellence Level,

Diligent Level, and Improvement Level) through the AI learning situation analysis tool on the Chaoxing Platform and pre-class tests. Students at the Basic Level (Diligent Level + Improvement Level) focus on the verification of algorithm principles (e.g., implementation of DCT transform), while students at the Advanced Level (Top Excellence Level + Academic Excellence Level) can explore compression optimization based on large models (e.g., Stable Diffusion image reconstruction). Flexible course tasks of different difficulties are assigned to students according to their individualized learning needs, and adjustments are made dynamically based on students' performance. For example, in the chapter on "image compression coding", micro-courses on JPEG principle animations and code debugging assistance are recommended for students at the Basic Level, while research topics on AI-generated cross-modal compression algorithms are recommended for students at the Advanced Level.

3.2.2 AI adaptive learning platform

AI evaluation tools are introduced to diagnose learning difficulties in real time and formulate personalized learning paths for different students. At the same time, an AI intelligent task engine can be used to encourage students to achieve a competence leap from mastering knowledge points to developing small projects. When each student can gain immediate a sense of accomplishment by overcoming challenging tasks on their exclusive learning path, the learning of complex algorithms is no longer a boring accumulation of formulas but evolves into an intelligent journey full of exploration fun. The task-based progressive learning path not only stimulates students' learning motivation but also improves teaching efficiency, and further sows the seeds of technological innovation in students' minds.

3.2.3 "1 + N" competition incentive mechanism

With "course design + discipline competitions" as the starting point, all students are required to complete 9 industrial application projects. Outstanding students are encouraged to participate in competitions closely related to the development of AI technology, such as the "China University Computer Competition" and the "Blue Bridge Cup National Software and Information Technology Professionals Competition". Support in terms of corporate mentors, on-the-spot algorithm engineers from

the Internet industry, and computing resources is provided.

3.3 Intelligent Leapfrogging

3.3.1 Hierarchical guidance with micro-courses + task sheets

Driven by the intelligent hierarchical engine, the course innovatively develops a dual-track learning system of "micro-knowledge points + task ladders". The system conducts real-time analysis of students' code debugging behaviors, experimental report quality, and test answer data through the Chaoxing AI evaluation tool, and automatically generates students' personal profiles. For complex modules such as image segmentation, 3-minute micro-course task sheets with principle animation are set up for students with weak foundations to help them establish an intuitive understanding of basic principles; for advanced students, in-depth analysis micro-course task sheets on the evolution of cross-modal segmentation algorithms are provided, allowing them to directly engage in the learning of cutting-edge AI algorithms in the field of image segmentation. The supporting hierarchical task sheets adopt a three-level structure of "foundation consolidation - advanced breakthrough - innovative application".

3.3.2 AI model practical training to construct multiple image processing scenarios

Centering on the three modules of "Image Foundation - Core Algorithms - Industrial Application", the course helps students master image processing technologies through 9 life-related cases. Through cases such as mobile phone album management and handwritten digit recognition, the principles of image digitization and color processing are explained, and students use simple Matlab code to realize photo classification and filter effects. The core algorithm module focuses on practical technologies such as document enhancement and traffic sign detection, and uses existing OpenCV functions to complete operations such as shadow removal and edge detection, reducing the difficulty of algorithm implementation. The industrial application module covers scenarios such as agricultural product grading and garbage classification, and demonstrates the technical chain of color recognition and feature extraction through complete projects.

4. Reform Effects

4.1 Abundant Achievements in Competitions and Scientific Research

Since 2020, 100% of students have participated in competitions such as the "China University Computer Competition", "Blue Bridge Cup", and "Datang Cup". They have won more than 100 provincial and above-level awards, and the award-winning rate has increased year by year, which has greatly stimulated students' enthusiasm for learning and participating in competitions.

4.2 Students' Participation in Scientific Research Projects to Verify the Effect of Curriculum Reform

Undergraduate students have co-published more than 10 papers with teachers, and teachers and students have jointly obtained 12 software copyrights. More than 30 students have presided over or participated in college students' innovation and entrepreneurship projects, including 5 provincial and above-level projects, and 3 excellent graduation theses. In addition, many students have participated in teachers' scientific research projects, forming a teacher-student learning community and realizing the feedback of scientific research to teaching.

4.3 High Student Satisfaction Proves the Effect of Curriculum Reform

After the teaching innovation, students' learning enthusiasm and initiative have been greatly enhanced, and their satisfaction with the course has increased year by year. Students feel that the course can inspire innovative thinking and enable them to apply knowledge to practice. According to students' feedback, the project-based teaching method and the student-led project presentation method have significantly improved their confidence, and they have highly praised the course.

4.4 Course Evaluation and Multiple Honors Demonstrating Demonstration and Leadership

The course teaching team uses AI technology to empower teaching innovation. Through the reform of the *Digital Image Processing* course, it continuously improves teaching innovation measures and effectively solves course teaching problems. The teaching reform experience has

been extended to 5 courses, including *Modern Switching Technology*, *Communication Principles*, *Mobile Communication*, *Optical Fiber Communication*, and *Data Structures*, forming an "AI + Communication" course group. Based on this "AI + Communication" course group, members of the teaching team have won 18 provincial and above-level teaching competition awards for their related achievements, established 9 teaching reform projects, and the team teachers have undertaken 4 demonstration courses at the university and college levels, fully demonstrating the demonstration role of the teaching reform.

5. Conclusion

The teaching reform, which deeply empowers the entire teaching process with AI technology and constructs the "Foundation Building - Scenario Deepening - Intelligent Leapfrogging" three-stage talent cultivation model, effectively addresses core pain points such as fragmented knowledge, differentiated foundations, and disconnected application. It builds a new student-centered, personalized, intelligent, and practical teaching system. Practice fully proves that this model significantly improves teaching quality, students' learning effects, practical innovation capabilities, and comprehensive quality. The cultivation effect has been recognized by multiple parties including students, competition judges, and enterprises, and the reform experience has strong promotion value. In the future, the team will continue to deepen the application of AI technology in teaching and make greater contributions to cultivating compound innovative talents who can adapt to the development of the future intelligent communication industry.

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References

- [1] Gong Shufen, Fang Yuyuan, Hu Huanhuan, et al. Innovation and Practice of Blended Teaching Mode in Course of "Environmental Engineering Microbiology". Research and Exploration in Laboratory,

- 2025, 44(9): 165-172.
- [2] Mao Haijie, Jiang Dongnian, Su Min. Quality Feedback and Continuous Improvement Practice of "Comprehensive Training in Control Theory" Course. *Electrical Engineering*, 2025, 26(7): 56-61.
- [3] Wang Linling, Wang Tao. AI-Empowered Situational Teaching: A Preliminary Exploration of the Integration of Teaching and Examination in County High School Chinese Language Education. *Chinese Language Learning*, 2025(5): 67-71.
- [4] Zhu Mingliang, Kang Ziyang, Ge Kunpeng, et al. Innovative Practice of the "3S Teaching Model" Based on Smart Education: A Case Study of the Mobile Communication Course. *Higher Education and Practice*, 2024, 1(6): 142-147.
- [5] Wang Feng, Pan Qing, Yuan Ling. Curriculum Quality Improvement for Analogy Circuits Based on Engineering Education Accreditation. *Education and Teaching Forum*, 2020(15): 308-309.
- [6] Zhang Yan. Research on Quality Monitoring and Continuous Improvement of Mechanical Manufacturing Process Course. *China Educational Technology & Equipment*, 2024(20): 62-66.
- [7] Wu Xiaotao, Guo Xin, Jiang Qin. Research and Practice of Ideological and Political Teaching in "Numerical Analysis" Course Based on BOPPPS. *Journal of Huanggang Normal University*, 2025, 45(5): 82-88.
- [8] Long Xuan. Research on Course Quality Evaluation and Continuous Improvement Based on NLP and Causal Inference. Xiangtan University, 2023.
- [9] Zhang Lanlan. Quality Improvement of the Database Principle and Application Experiment Course Based on the PDCA Cycle Theory. *Office Automation*, 2024(6): 7-9.
- [10] Long Xuan, Duan Bin, Ke Qicong. Research on Continuous Improvement Model of Course Quality Evaluation Based on Learning Confounding Control. *Electrical Engineering*, 2022, 23(10): 68-73.
- [11] Wang Jian, Zhang Jingliang, Qu Xiaoying, et al. Construction and Practice of a University Mathematics Teaching System for Cultivating Undergraduate Innovation Ability. *Journal of Higher Education*, 2025(25): 24-28.
- [12] Deng Jiaojiao. Research on the "Three-Stage Progressive, Four-in-One" Ideological and Political Education Model under Cultural Inheritance. *Education Theory and Practice*, 2025(2): 133-135.
- [13] Wang Jing, He Xuezhi. Construction of a "Three-Stage Immersive" Anatomy Teaching Model Empowered by Intelligent Technology. *Basic Medical Education*, 2025, 27(9): 857-861.