ISSN: 2688-8653

Teaching Reform and Practice of "Modern Signal Processing" in the Intelligent Era

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Abstract

With the rapid development of technology, modern signal processing has been widely applied in various fields such as communication, image processing, medical imaging, and bio-informatics. For graduate students majoring in electronic information engineering, communication engineering, and related fields, mastering the theories and techniques of modern signal processing is particularly important. However, the traditional "Modern Signal Processing" course presents challenges such as abstract content, complex mathematical derivations, and high difficulty in understanding for students. Therefore, this paper aims to explore the teaching reform and practice of the "Modern Signal Processing" course in the intelligent era. By optimizing teaching content, innovating teaching methods, and introducing diversified evaluation mechanisms, the goal is to enhance students' learning interest and practical abilities to meet the needs of the times.

Keywords

Artificial Intelligence; Modern Signal Processing; Teaching Reform.

1. Introduction

"Modern Signal Processing" is a crucial specialized course for electronic information majors. It encompasses knowledge from multiple courses such as signals and systems, digital signal processing, and stochastic signal analysis. The course is characterized by extensive mathematical theory derivations, broad content, and abstract concepts [1-3]. Given that engineering graduate students generally have limited mathematical theory proficiency and the course hours are constrained, traditional teaching methods often make it difficult for students to understand and grasp the course content, sometimes even leading to a sense of fear. Therefore, the teaching reform of the "Modern Signal Processing" course is particularly urgent.

With the rapid development of information technology, signal processing technology plays an increasingly important role in various fields such as communication, radar, sonar, biomedical, and image processing. As an important specialized course, "Modern Signal Processing" covers topics such as stochastic signal analysis, parameter estimation, spectral estimation, adaptive filtering, and time-frequency analysis, providing students with opportunities to deeply understand and master the theories and methods of signal processing. However, traditional teaching of "Modern Signal Processing" faces several issues, such as abstract content, monotonous teaching methods, and insufficient practical teaching, which fail to meet the modern society's demand for high-quality signal processing talents [4-7].

Artificial intelligence (AI), a hot topic in today's technology field, has strong data analysis and processing capabilities and has been widely applied in the field of signal processing [8]. Integrating AI with the "Modern Signal Processing" course can bring new ideas and methods to teaching, improve teaching quality, and cultivate students' innovation and practical abilities.

2. Problems in Teaching "Modern Signal Processing"

(1) Course Content

ISSN: 2688-8653

Abstract and Difficult Content: "Modern Signal Processing" involves a large amount of mathematical theory and algorithms, such as Fourier transform, filter design, and spectral estimation. These topics are quite challenging for students with weak mathematical foundations. Additionally, due to limited course hours, teachers often find it difficult to thoroughly explain complex theories, leading students to only scratch the surface and struggle to form a systematic knowledge framework.

Extensive Content: The course covers a wide range of knowledge, including stochastic signals, parameter estimation theory, adaptive filters, higher-order statistical analysis, and time-frequency signal analysis. The numerous and interrelated knowledge points require students to grasp a large amount of information in a limited time, which can easily lead to confusion and forgetfulness.

Rapid Content Updates: The field of modern signal processing evolves rapidly, with new concepts, methods, and technologies constantly emerging, such as compressed sensing and sparse representation. Due to reasons related to textbook writing and course arrangement, the course content often lags behind actual technological developments. This lag not only affects students' understanding and mastery of the latest technologies but also diminishes the course's practicality and appeal.

(2) Teaching Methods

Monotonous Teaching Methods:** Traditional teaching methods primarily involve teachers writing on the board, explaining theories, and deriving formulas, with students passively receiving knowledge. This lack of initiative and engagement results in a dull classroom atmosphere, which is not conducive to cultivating students' innovative thinking and independent learning abilities. Moreover, given the extensive and in-depth content of the course, a single teaching method often fails to meet the diverse learning needs of students, leading to frustration for some during the learning process.

Insufficient Integration of Theory and Practice:** The teaching process often overemphasizes theoretical knowledge while neglecting the importance of practical teaching. As a result, students may grasp certain theoretical knowledge but struggle to apply it in practice, unable to flexibly use what they have learned to solve real-world problems.

Lack of Interaction:** There is limited interaction between teachers and students and among students themselves during classroom teaching. This makes it difficult for teachers to understand students' learning difficulties and problems, and students lack opportunities for communication and collaboration, which is not conducive to developing their teamwork and communication skills.

(3) Student Issues

Diverse Student Backgrounds:** Graduate students come from different institutions and majors, resulting in significant differences in their mathematical foundations, professional backgrounds, and learning abilities. Some students may not have a solid grasp of prerequisite knowledge such as advanced mathematics, probability theory, and signals and systems before studying "Modern Signal Processing," posing challenges for teaching and making it difficult for teachers to provide targeted instruction based on students' actual situations.

Lack of Motivation and Independent Learning Ability:** Due to the abstract and challenging nature of the course content, some students may develop a sense of difficulty and lack motivation and interest in learning, leading to poor learning outcomes. The long-term traditional teaching model has fostered a habit of passive knowledge reception, resulting in weak independent learning abilities. Students are not adept at actively thinking, consulting materials, and exploring new knowledge, which does not meet the requirements of the "Modern Signal Processing" course for independent learning abilities.

ISSN: 2688-8653

3. Application of Artificial Intelligence in Modern Signal Processing

With the rapid development of technology, artificial intelligence (AI) has permeated various industries, with significant impact in the field of modern signal processing [8]. The introduction of AI has not only greatly enhanced the efficiency and accuracy of signal processing but also opened up a series of new application scenarios.

(1) Powerful Data Processing Capabilities

In modern signal processing, AI technology first demonstrates powerful data processing capabilities. Traditional signal processing methods often rely on complex mathematical models and algorithms, which are inadequate for large-scale, high-dimensional data processing. AI technologies, especially deep learning and neural networks, can automatically learn and extract useful features from large amounts of data, enabling precise analysis and processing of signals. This capability is particularly prominent in fields such as speech signal processing and image recognition, allowing machines to automatically recognize and understand human speech commands and automatically recognize and classify images, providing strong technical support for smart homes and intelligent security [9-12].

(2) Intelligent and Automated Signal Processing

AI technology has also brought intelligence and automation to the field of signal processing. Through machine learning and intelligent algorithms, machines can automatically adjust parameters, optimize performance, and even make autonomous decisions based on input signal data. This capability has been widely applied in intelligent transportation systems and autonomous driving. For example, intelligent transportation systems can intelligently adjust traffic light timings by sensing and analyzing vehicle signal data, optimizing traffic flow; autonomous driving technology can autonomously make decisions and control vehicle movement by sensing and analyzing the surrounding environment's signal data, greatly improving traffic efficiency and safety [13].

(3) Strong Predictive and Classification Capabilities

AI technology also exhibits strong predictive and classification capabilities in modern signal processing. AI-based predictive and classification algorithms can accurately predict and classify signals, enabling intelligent applications in the field of signal processing. For example, in financial risk control, AI technology can analyze and predict market signals, providing more accurate risk assessments and investment advice; in medical diagnosis, AI technology can support more precise medical image diagnosis, improving early detection rates of diseases [14-15].

4. Methods and Measures for Introducing AI into "Modern Signal Processing" Teaching

(1) Adjusting Teaching Content

Incorporating AI-Related Content:** Introduce the basic principles, development history, and application fields of AI technology, especially deep learning and neural networks related to signal processing, in the "Modern Signal Processing" course. This helps students understand the importance of AI in signal processing. For example, the application of deep learning in speech signal processing, image signal processing, and biomedical signal processing. Students should be made aware of the latest developments and application prospects of AI in signal processing.

Integrating Course Content:** Integrate AI-related content with traditional signal processing content, enabling students to better understand and master the basic theories and methods of signal processing while learning about AI applications in signal processing. For example, when

ISSN: 2688-8653

explaining time-frequency analysis, introduce how convolutional neural networks in deep learning can be used for time-frequency analysis of signals.

Updating Teaching Cases:** Select representative cases of AI applications in signal processing, such as speech recognition, image classification, and object detection, as teaching cases. Through the analysis and solution of actual cases, students can deeply understand the basic theories and methods of signal processing and learn about AI applications in signal processing.

(2) Innovating Teaching Methods

Case-Based Teaching:** Use actual case analysis and solutions to help students deeply understand the basic theories and methods of signal processing and learn about AI applications in signal processing. For example, when teaching speech signal processing, choose a real speech recognition case, allowing students to analyze the characteristics of speech signals, the basic principles and methods of speech recognition, and how to use deep learning algorithms for speech recognition.

Project-Driven Teaching:** Divide students into groups, with each group selecting a project related to signal processing and AI, such as designing a speech recognition system or an image classification system. Through project implementation, students can master the basic theories and methods of signal processing and AI while developing teamwork and innovation skills.

Utilizing Online Teaching Resources:** Use online teaching platforms, such as MOOCs and micro-courses, to provide students with rich teaching resources, including teaching videos, courseware, and exercises. This allows students to choose learning content based on their progress and needs, improving learning efficiency.

Enhancing Practical Teaching:** Strengthen practical teaching components, allowing students to master the basic theories and methods of signal processing and AI through experiments and course design while improving their practical and innovation abilities. For example, in experimental teaching, students can use deep learning frameworks such as TensorFlow and PyTorch to process and analyze speech and image signals.

5. Reforming Experimental Teaching

Increasing Design and Comprehensive Experiments： Reduce the proportion of verification experiments and increase the proportion of design and comprehensive experiments. This allows students to comprehensively apply their knowledge of signal processing and artificial intelligence to solve real-world problems. For example, in a speech signal processing experiment, students can design a speech recognition system, including stages such as speech signal acquisition, preprocessing, feature extraction, model training, and recognition.

Open Experimental Environment:Create an open experimental environment where students can conduct experiments independently during their free time. Provide necessary experimental equipment and software environments for students, and arrange for teachers to offer guidance and answer questions.

Introducing Competition Mechanisms: Organize students to participate in competitions related to signal processing and artificial intelligence, such as the National College Student Electronic Design Contest and the National College Student Intelligent Car Competition. Through competitions, students' interest in learning and innovation abilities can be stimulated, while also improving their practical skills and teamwork abilities.

6. Optimizing Assessment Methods

Diversified Assessment Methods: Adopt diversified assessment methods, including final exams, regular assignments, experimental reports, and project designs. This comprehensive approach assesses students' learning outcomes and overall qualities.

ISSN: 2688-8653

Emphasizing Process Assessment: Strengthen the assessment of students' learning processes, including classroom performance, assignment completion, and participation in experiments. This encourages students to focus on continuous learning and improves their learning outcomes.

Increasing the Weight of Ability Assessment: Increase the proportion of assessments focused on students' practical abilities, innovation capabilities, and comprehensive application skills. For example, in project design assessments, emphasize evaluating students' project design ideas, innovation points, and implementation effects.

7. Conclusion

Integrating artificial intelligence with the "Modern Signal Processing" course is an important direction for current signal processing teaching reform. Through measures such as adjusting teaching content, innovating teaching methods, reforming experimental teaching, and optimizing assessment methods, teaching quality can be improved, and students' innovation and practical abilities can be cultivated. This enables students to better adapt to the development needs of the modern signal processing field. In the process of teaching reform, teachers need to continuously explore and innovate, combining students' actual situations and needs to develop feasible teaching plans, thereby contributing to the cultivation of high-quality signal processing talents.

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