

Research and Practice of Intelligent Network Operation and Maintenance Teaching Driven by Large Language Models

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Abstract: With the rapid development of artificial intelligence technology, large language models are gradually being integrated into various industry applications. In the field of network operations and maintenance, the traditional manual operation mode can no longer cope with complex network architectures and massive maintenance data. Firstly, the system studied the current applications and development trends of large language models in intelligent network operations and maintenance. Then, it deeply analyzed the existing problems in current network operations teaching. Finally, it proposed a network operations teaching reform program based on large language models, including curriculum system reconstruction, teaching mode innovation, and practical platform construction. Through teaching practice, it was found that integrating large language model technology into network operations teaching can effectively enhance students' intelligent maintenance capabilities. The proposed large language model-driven network intelligent operations teaching reform program provides theoretical reference and practical guidance for the reform of practical teaching in university network engineering programs.

Keywords: Large Language Models; Networks; Intelligent Operations and Maintenance; Teaching.

1. Introduction

In the process of digital transformation, enterprises' IT infrastructure is undergoing unprecedented changes [1]. The wide application of emerging technologies such as cloud computing, big data, and the Internet of Things has made network architecture increasingly complex [2]. Traditional manual operation and maintenance models can no longer meet the business development needs of enterprises [3]. By 2025, more than 60% of enterprises worldwide are expected to adopt AIOps (Artificial Intelligence for IT Operations) technology for the modernization and intelligent transformation of traditional IT operations[4]. This development trend presents new requirements for the cultivation of traditional network operation and maintenance capabilities in network engineering students and necessitates analyzing and studying problems in the theory and practice teaching of traditional network operation and maintenance-related courses, providing solutions. Large Language Models (LLMs), as popular technologies in the field of artificial intelligence, are profoundly changing the way various industries work[5]. LLMs such as ChatGPT, DeepSeek, and Kimi, with their powerful natural language understanding, knowledge reasoning, and code generation capabilities, provide new technologies for intelligent network operation and maintenance[6-8]. In recent years, numerous enterprises and research institutions at home and abroad have explored the application of large language models in operation and maintenance scenarios, achieving good results[9-10]. Introducing large language model technology into network operation and maintenance teaching can not only help students master cutting-edge technologies but also cultivate intelligent operation and maintenance thinking and practical abilities.

This paper systematically studies the application of large language model technology in intelligent network operation

and maintenance, thoroughly analyzes the existing problems in current network operation and maintenance teaching, proposes a teaching reform plan based on large language models, and verifies the effectiveness of the plan through teaching practice.

2. The Current Status of Large Language Model Applications in Network Operations and Maintenance

Large language models refer to artificial intelligence models based on the Transformer architecture, trained on massive amounts of text data, and possessing powerful language understanding and generation capabilities. The current major foreign large language models include OpenAI's GPT, Anthropic's Claude, Google's PaLM, and Meta's LLaMA; domestically, they include ByteDance's Doubao, Alibaba's Tongyi Qianwen, Deepseek's Deepseek, Baidu's Wenxin Yiyan, and Moonlit Side's Kimi. These models continuously achieve breakthroughs in terms of parameter scale, training data volume, and performance capabilities. Large language models have unique technical advantages in the field of network operations, including natural language understanding capabilities, enabling them to parse operation and maintenance documents, log information, and alarm descriptions; code generation capabilities, assisting in writing automation scripts and configuration files; knowledge reasoning capabilities, supporting root cause analysis and solution recommendations; and multimodal processing capabilities, allowing them to comprehensively analyze data from various sources such as metrics, logs, and topology.

Currently, the specific applications of large language models in operation and maintenance scenarios primarily include intelligent alarm handling, fault diagnosis and root

cause analysis, automated script generation, and operations knowledge management. Large language models can perform semantic understanding and intelligent classification of massive alarm information, achieving automatic alarm noise reduction, correlation analysis, and prioritization. By integrating multimodal data such as logs, metrics, and topology, large language models can perform deep reasoning and quickly locate the root cause of faults. Large language models can automatically generate automation operation scripts such as Python and Ansible based on natural language descriptions, significantly lowering the threshold for script writing. Based on retrieval-augmented generation (RAG) technology, large language models can build enterprise-specific operations knowledge bases, supporting intelligent Q&A and knowledge recommendation.

The core capabilities of the new generation of intelligent operations and maintenance can be summarized as a closed loop of perception-analysis-decision-execution. Intelligent perception capability is achieved through multi-source data integration, enabling comprehensive awareness of network status. This includes device status monitoring, traffic analysis, log collection, topology discovery, and more, constructing a digital twin of network operations. Intelligent analysis capability uses machine learning and large language model technologies to deeply analyze the collected data. This includes anomaly detection, trend forecasting, correlation analysis, root cause localization, and extracting valuable information from the data. Intelligent decision-making capability generates optimal handling strategies based on analysis results and knowledge bases. Large language models can understand complex business scenarios, perform logical reasoning, and provide explainable decision recommendations. Automatic execution capability turns decisions into concrete operational instructions, executed through automation tools. It supports gradual deployment and rollback mechanisms, ensuring operational safety and controllability.

3. Current Situation and Problems of Network Operation and Maintenance Course Teaching

3.1. Current Teaching Situation of Network Operation and Maintenance Courses

Network operation and maintenance-related courses in the Network Engineering major mainly adopt the traditional teaching model of theoretical instruction combined with experimental verification. Theoretical teaching focuses on the explanation of basic knowledge, such as network protocols, device configuration, and troubleshooting; the experimental sessions involve configuration practice through simulators, such as GNS3, EVE-NG, Packet Tracer, or real equipment. Although project-based learning and case teaching have been introduced, overall, the connection with industry practice is still insufficient. The Network Engineering major offers network operation and maintenance-related courses, but the content involving intelligent operation and maintenance is relatively limited.

3.2. Problems in Network Operations and Maintenance Course Teaching

Currently, the teaching of courses related to network operations and maintenance mainly has the following

problems:

(1) Course content lags behind technological development.

Network operations and maintenance technologies are updated quickly, but textbooks and course content often lag behind industry practice by 3-5 years. Cutting-edge technologies such as large language models and intelligent operations have not yet been systematically incorporated into the curriculum, so students require a relatively long adaptation period after graduation.

(2) Practical teaching is disconnected from real scenarios.

Laboratory environments are difficult to simulate large-scale, complex enterprise network scenarios, and students lack experience in handling real operation and maintenance problems. Traditional verification experiments are insufficient to cultivate students' fault analysis and problem-solving abilities.

(3) Insufficient cultivation of automation and programming skills.

Modern network operations increasingly emphasize infrastructure as code and automation thinking, but existing courses do not teach automation tools such as Python and Ansible in depth, leaving students' programming skills and automation thinking to be strengthened.

(4) Lack of awareness of intelligent operations.

Students lack understanding of the application of AIOps and machine learning in operations, making it difficult to adapt to the development trend of intelligent operations. The rapid development of large language model technologies presents new requirements for the skill structure of operations personnel.

(5) Insufficient interdisciplinary integration.

The cross-disciplinary integration of network operations with software development, data analysis, artificial intelligence, and other fields is deepening, but the current curriculum system is relatively closed, lacking the cultivation of interdisciplinary vision and abilities.

4. Large Language Models Empower Network Operations and Maintenance Course Teaching

4.1. The Role of Large Language Models in Teaching

In network operations teaching, large language models can play multiple roles, forming a new teaching paradigm of "teacher-student-machine" collaboration.

(1) Intelligent Teaching Assistant. Large language models can act as intelligent assistants for teachers, helping with lesson preparation, generating teaching cases, grading assignments, and answering student questions. Teachers can devote more effort to instructional design and personalized guidance.

(2) Learning Companion. Students can interact with large language models at any time to receive immediate learning support and feedback. Large language models can provide personalized explanations and guidance based on the students' questions, achieving one-on-one personalized tutoring.

(3) Practical Guide. In experiments and project practice, large language models can guide students through operations, explain command meanings, analyze error causes, and recommend solutions, enhancing the effectiveness of practical learning.

(4) Knowledge Engine. Large language models integrate

vast amounts of network technology knowledge and can serve as a knowledge base for students to consult at any time, supporting natural language queries and intelligent recommendations.

4.2. Teaching Scenarios Supported by Large Language Models

Based on the technical characteristics of large language models, the following scenarios can be implemented in network operations teaching.

(1) Intelligent Lesson Preparation and Content Generation. Teachers can use large language models to quickly generate teaching outlines, courseware content, lab manuals, and test questions. By inputting teaching objectives and requirements, large language models can automatically generate teaching materials that meet the requirements, greatly improving lesson preparation efficiency.

(2) Personalized Learning Paths. Based on students' learning progress, knowledge mastery, and interests, large language models can recommend personalized learning content and exercises, achieving teaching tailored to individual students.

(3) Intelligent Experiment Guidance. During experiments, students can seek help from large language models when encountering problems. Large language models can understand experimental scenarios, analyze student operations, and provide targeted guidance rather than directly giving answers.

(4) Code Review and Optimization. Students' automated scripts or configuration files can be submitted to large language models for review. The models can check for syntax errors, logical issues, and provide optimization suggestions, cultivating students' awareness of code quality.

(5) Fault Scenario Simulation. Using large language models to generate realistic network fault scenarios and cases, students can conduct troubleshooting drills in virtual environments, gaining practical experience.

(6) Learning Outcome Assessment. Large language models can analyze students' learning behaviors and assignment performance, generate learning reports, and help teachers understand students' learning status, allowing timely adjustment of teaching strategies.

5. A Reform Plan for Network Operation and Maintenance Teaching Based on Large Language Models

5.1. Curriculum System Reconstruction

Based on the development trends of large language models and intelligent operations and maintenance (O&M), it is necessary to systematically reconstruct the curriculum system related to network O&M, forming a three-tier course structure of "Foundation-Intermediate-Frontier."

Foundation-level courses: Includes "Network Fundamentals," "Python Programming," "Linux System Administration," etc., to consolidate students' basic knowledge of networking and programming skills. At this level, large language models are introduced as learning aids to help students understand basic concepts and write simple scripts.

Intermediate-level courses: Includes "Network Automation and O&M," "Cloud Computing and Container Technology,"

"Network Monitoring and Observability," etc., to cultivate students' practical skills in automated O&M. At this level, large language models can serve as code generation assistants and troubleshooting tools, enhancing students' practical efficiency.

Frontier-level courses: Includes "Intelligent O&M and AIOps," "Large Language Model Technologies and Applications," "Network Agent Development," etc., enabling students to master cutting-edge technologies and innovative methods. At this level, students need to deeply understand the working principles of large language models and learn to design and develop intelligent O&M applications.

5.2. Innovation in Teaching Modes

Adopt a blended teaching mode of "online self-learning, offline interactive seminars, and AI-assisted practice." Before class, students learn basic knowledge through online platforms, with large language models providing intelligent Q&A support; during class, teachers focus on key and difficult points for explanation, organize group discussions and case analyses; after class, students complete experiments and projects with AI assistance.

Use real enterprise projects as teaching carriers to organize students for team collaboration. Projects cover the complete O&M process including network planning and design, automated deployment, monitoring and alerts, and fault handling. Large language models serve as project advisors, providing technical guidance and solution recommendations.

Build a cloud-based virtual simulation laboratory environment, simulating large-scale enterprise network scenarios. Students can freely operate and learn through trial and error in the virtual environment. Large language models can act as lab instructors, analyzing students' operations in real-time and providing feedback and suggestions.

5.3. Practice Platform Construction

Construct an integrated "cloud-edge-end" network O&M practice platform to support experimental teaching needs of multiple levels and scenarios. Build large-scale network lab environments on public or private clouds, supporting experiments on advanced technologies such as SDN, NFV, and container networks. The platform integrates large language model services, providing smart Q&A, code generation, and fault analysis functions. Provide virtual machine images and containerized lab environments so that students can build lab setups on personal computers. Configure local deployment solutions for large language models to ensure AI-assisted capabilities in offline environments. Retain necessary real network devices for essential hands-on training. Through remote access, students can conduct device configuration experiments anytime and anywhere.

6. Practical Cases and Effect Analysis

6.1. Case Study of Teaching Reform Practice

A university's Network Engineering program conducted a pilot teaching reform in the Spring 2025 semester for network operation and maintenance courses based on large language models. The "Network Automation and Operations" course was taken as a pilot, introducing large language model-assisted teaching. A campus-private deployment platform for large language model services was built using open-source large language models (such as ChatGLM, Llama, etc.),

integrating a knowledge base in the field of network operation and maintenance, including course textbooks, lab guides, technical documents, and enterprise cases. For network operation and maintenance teaching scenarios, a series of teaching intelligent agents were developed to answer technical questions, generate configuration scripts, guide lab operations, analyze error causes, check student code, and provide optimization suggestions. The original verification experiments were transformed into inquiry-based experiments, designing project tasks based on real scenarios. For example, students were required to use Python and Ansible to complete an automated configuration task for a multi-vendor network, using large language models to assist in script development and debugging. Before class, students studied foundational knowledge independently via an online platform, with the large language model providing 24-hour intelligent Q&A; during class, teachers organized case discussions and explained difficult points; after class, students completed experiments and projects with the assistance of the large language model.

6.2. Analysis of Teaching Effectiveness

After one semester of teaching practice, the following outcomes were achieved:

(1) Significant improvement in learning efficiency. Students had more convenient channels for obtaining help, with response time to queries reduced from an average of 2 hours (waiting for teacher feedback) to instant response. Student feedback indicated that the large language model could understand their questions well and provided clear and easy-to-understand answers.

(2) Noticeable enhancement of practical skills. Experiment completion rates increased from 78% to 95%, and the excellence rate rose from 25% to 42%. Students were able to independently complete more complex automated operation and maintenance tasks, and the quality and standardization of their code also improved significantly.

(3) Increased learning interest and initiative. The interactive learning method of the large language model was well-received by students, with both the number and quality of student questions improving. More students actively explored extracurricular knowledge, participating in open-source projects and technical communities.

(4) Reduced teacher workload. The large language model took on most of the repetitive Q&A tasks, allowing teachers to devote more energy to teaching design, personalized guidance, and teaching research. Teacher satisfaction surveys show that 85% of teachers believe that large language model-assisted teaching improved work efficiency.

7. Conclusion

Large language models are auxiliary tools rather than substitutes. Large language models can effectively improve teaching efficiency, but they cannot completely replace the role of teachers. Teachers have irreplaceable value in designing teaching activities, guiding deep learning, and cultivating critical thinking. The quality of the knowledge base determines the effectiveness of large language models. The quality of responses from large language models heavily depends on the content and structure of the knowledge base. Efforts need to be made to build high-quality professional knowledge bases and continuously update and maintain them.

It is necessary to cultivate students' AI literacy. Students need to learn how to correctly use large language models, including questioning skills, result verification, and critical thinking. This helps prevent students from over-relying on large language models and losing the ability to think and solve problems independently. Data security and privacy protection cannot be ignored. Although privatized deployment increases technical complexity, it is necessary to protect teaching data and student privacy. A sound data management system needs to be established. This paper systematically studies the application status of large language model technology in automated and intelligent network operations and maintenance, deeply analyzes the current problems in network operations teaching, proposes a teaching reform plan based on large language models, and verifies the effectiveness of the plan through practical cases.

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