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AI-Based Intelligent Information System Operation and Maintenance

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Abstract: This paper focuses on AI intelligence as the fundamental direction to conduct research on information system operation and maintenance (O&M). Combining current AI-supported technologies in information system O&M, it proposes O&M strategies such as intelligent fault prediction and diagnosis, intelligent system performance optimization, intelligent system security protection, and adaptive system O&M implementation. Practical applications reveal that AI intelligence technology offers significant advantages in information system O&M, effectively addressing pain points of traditional O&M techniques, such as low fault prediction rates, slow repair speeds, poor security interception, and high labor costs. This substantially enhances the effectiveness of information system O&M.

Keywords: Information system operation and maintenance; Intelligence; Fault prediction and diagnosis; Performance optimization; Security protection

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1. Introduction

In the current information age, the quality of information system operation and maintenance (O&M) directly impacts service efficiency and business continuity. Traditional O&M models face challenges such as excessive reliance on manual labor and delayed responses, which are unable to meet the actual O&M needs of information systems [1]. AI-based intelligent O&M leverages artificial intelligence technologies to transform traditional O&M from a passive response model to a proactive prediction and automatic decision-making model. It enables early prediction of information system failures, dynamic system optimization, and real-time interception of security threats. Therefore, in information system O&M, researchers should actively introduce AI intelligence technologies to further refine their application and development logic, promoting the intelligent development of information system O&M.

1.1. AI-powered intelligent support technologies in information system operation and maintenance

AI-powered intelligent O&M of information systems primarily commence with data processing, pattern recognition, and knowledge organization, providing intelligent technical support for the entire lifecycle of information system O&M. The main technologies involved include machine learning, deep learning, natural language processing, and knowledge graphs [2]. For instance:

(1) Machine learning techniques can automatically mine O&M patterns. For instance, supervised learning techniques can train models based on historical fault data to accurately identify known anomalies such as memory leaks and CPU failures. Unsupervised learning techniques can precisely capture unknown network risks, such as packet anomalies, in unlabeled data, enabling timely fault warnings;

(2) Deep learning techniques can process massive amounts of temporal data, such as logs and server metrics. For example, Long Short-Term Memory (LSTM) networks can use disk input and output data as a basis to predict full-load risks in advance [3]. Convolutional Neural Networks (CNNs) can extract features from hardware monitoring images to accurately identify various equipment status anomalies, ensuring effective temporal analysis;

(3) Natural language processing techniques can reasonably transform unstructured data, such as O&M documents, alert information, and logs, into structured data. For instance, semantic matching and aggregation techniques can correlate alerts for different faults originating from the same source, automatically parse O&M manuals, and generate comprehensive fault troubleshooting steps, providing scientific and complete data support for information system fault diagnosis [4];

(4) Knowledge graph techniques can comprehensively integrate O&M knowledge, constructing an entity relationship network among devices, topologies, and faults. This enables efficient tracing of fault transmission paths, accurate fault localization, and effective association with historical fault case solutions, significantly reducing fault localization time and improving information system O&M efficiency.

Through the synergistic effects of these four AI-powered intelligent technologies, a solid intelligent foundation can be established for information system O&M, ensuring dual guarantees of O&M efficiency and quality [5].

2. Information system operation and maintenance strategies supported by AI-powered intelligent technologies

2.1. Intelligent fault prediction and diagnosis

To address issues in traditional information system operation and maintenance, such as low efficiency in manual troubleshooting and repair, and long system recovery times, researchers can introduce AI intelligence technologies into operation and maintenance processes. Through methods like data integration, model prediction, and intelligent diagnosis, they can predict and diagnose system faults, transforming the traditional post-event handling model into a pre-event prevention and control model [6].

A unified intelligent data middleware platform can be used to comprehensively integrate multi-source operation and maintenance data, ensuring continuous time series for structured data indicators. Natural language processing technology can be employed to annotate key information in unstructured data, while knowledge graphs can be utilized to record topological data and the relationships between various devices, creating favorable conditions for subsequent system operation and maintenance data analysis. Simultaneously, a combined AI intelligent model for fault prediction and classification should be constructed.

Based on long short-term memory models, extensive historical data training can be conducted over extended periods to establish normal threshold ranges. If predicted values exceed these normal thresholds, the model will immediately trigger alerts. Historical fault cases can serve as labels for the fault classification model, enabling automatic identification of fault types based on real-time operational characteristics of the information system, thereby improving fault identification accuracy [7].

2.2. Intelligent system performance optimization

Under traditional information system operation and maintenance models, resource allocation is static, with a fixed number of servers. This situation often leads to resource waste during low operational periods and performance shortages during peak periods. To address these issues, researchers can leverage AI intelligence technologies to ensure a balance between system resource supply and demand, achieving precise matching effects by focusing on demand prediction and dynamic scheduling. An optimized distributed gradient boosting library can be utilized to fuse historical business data and real-time load data of the system, implementing resource demand predictions across different dimensions, such as short-term traffic fluctuation predictions and long-term business plan predictions.

Based on these predictions, elastic deployments can be made in advance on cloud servers to ensure that resource supplies in each dimension match actual demands. It can also automatically implement resource scheduling based on the forecast results. For instance, when CPU utilization exceeds 80%, vertical scaling can be achieved by increasing system memory or the number of cores; when the number of concurrent users approaches the system's capacity, horizontal scaling can be implemented by load balancing and adding server nodes [8]. During periods of low utilization, when system utilization falls below 30%, idle resources can be automatically released to reduce waste. This approach not only enables intelligent optimization of information system performance, further improving system operational efficiency, but also facilitates reasonable cost savings, meeting the demands for efficient and economical operation and maintenance of information systems.

2.3. Intelligent system security protection

Traditional information systems primarily rely on firewalls and antivirus software for security protection. However, in the face of unknown threats such as APT attacks and ransomware, these protective measures are severely inadequate and struggle to ensure system security. Based on this, researchers can leverage AI-driven intelligence to implement proactive protection against information system security threats through methods such as behavior baselines, anomaly identification, and automated handling [9]. A multi-dimensional security behavior baseline is constructed, encompassing baselines for routine operational behaviors like user login times and access privilege scopes, network behavior baselines such as system packet sizes and network port applications, and system file baselines like program registration records and program process states. Based on these baseline data records, AI technology is employed to create a comprehensive normal behavior template for the information system.

Depending on the actual situation, AI-driven algorithms and models are used to implement graded responses to detected system anomalies. For example, in the case of suspicious logins, machine learning models can identify abnormal behaviors, automatically lock anomalous accounts, and issue alerts; for abnormal port scans, deep learning models can immediately block attacking IP addresses; and for virus infections, reinforcement learning models combined with knowledge graph technology can automatically implement file encryption and system configuration modifications, promptly completing device isolation, antivirus triggering, and data recovery backup operations. This approach enables the immediate detection of anomalies in information systems and facilitates prompt and effective handling, significantly reducing the time and cost associated with addressing information system security incidents and successfully filling the gap in defending against unknown security vulnerabilities in traditional information system operation and maintenance models [10].

2.4. Implementation of adaptive system operation and maintenance

Under the traditional operation and maintenance model for information systems, many repetitive tasks, such as server deployment, backup and restoration, and log analysis, rely heavily on manual labor. This approach is not only inefficient but also prone to human errors [11]. To address these issues, researchers can leverage AI-powered intelligent technologies to implement adaptive operation and maintenance for systems through methods such as intelligent script generation and process orchestration. Script generation primarily relies on natural language processing (NLP) techniques to parse system administrator requirements into three key elements: time, object, and operation. Based on a template library, Shell/Python scripts are automatically generated, and intelligent verification of permissions and syntax is performed.

After script execution, real-time monitoring of the execution results is conducted using NLP models. If execution fails, the model can automatically retry the process and issue timely alerts based on the actual situation, thereby achieving an intelligent transformation from the traditional manual script-writing model for system operation and maintenance [12]. For complex cross-system operation and maintenance tasks, researchers can utilize knowledge graph technology in process orchestration to adaptively organize scheduling steps based on actual conditions. API calls for each system are executed in sequence, and system switching is automatically performed without manual intervention. This approach enables adaptive operation and maintenance of information systems, significantly improving system operation and maintenance efficiency while reducing labor costs.

3. Application effects and development prospects of AI intelligence technologies in the operation and maintenance of information systems

3.1. Application effects

To verify the application effects of AI intelligence technologies, such as machine learning, deep learning, natural language processing, and knowledge graphs, in the operation and maintenance of information systems, researchers comprehensively introduced these AI intelligence technologies into the operation and maintenance of a core system of an Internet enterprise. Considering the actual situation, they implemented intelligent operation and maintenance for the enterprise's core information system using the aforementioned operation and maintenance strategies. The AI intelligent operation and maintenance trial was scheduled from January 2024 to June 2024.

During the operation and maintenance period, researchers collected key indicator data, including fault detection rates, mean time to repair, system resource utilization rates, security threat interception rates, and labor costs for operation and maintenance. By comparing these data with those from traditional operation and maintenance models, they analyzed the application effects of AI intelligence technologies. The comparative analysis revealed that, compared to traditional operation and maintenance models, the AI intelligent operation and maintenance model reasonably optimized various operation and maintenance indicators for the enterprise's core information system, significantly enhancing overall system operational efficiency and security (**Table 1**).

Table 1. Comparison of key metrics between AI-based and traditional information system operations and maintenance models

No.	Key O&M metric	AI-driven O&M mode	Traditional O&M mode	Improvement
1	Fault detection rate	96%	72%	33.33%
2	Mean time to repair (MTTR)	42 min	4.8 hr	85.42%
3	System resource utilization	78%	45%	73.33%
4	Security threat blocking rate	94%	61%	54.10%
5	Labor cost (per unit)	45,000 CNY	150,000 CNY	70.00%

Data sourced from 2024 Annual Report on Information System Operation and Maintenance of An Internet Enterprise

Thus, it can be seen that the AI intelligent operation and maintenance model is more suitable for modern information system operation and maintenance than traditional models. By reasonably introducing key supporting technologies for AI intelligent operation and maintenance into information system operation and maintenance and formulating comprehensive technical plans and implementation strategies based on actual conditions, satisfactory operation and maintenance results can be achieved.

3.2. Development prospects

Although AI intelligence technologies have demonstrated significant advantages in current information system operation and maintenance, as the technology is in its initial application stage and the complexity of information systems and operation and maintenance requirements continue to increase, AI intelligence technologies should also evolve in accordance with the actual development and operation and maintenance needs of information systems. In the current field of information system operation and maintenance, the main development trends of AI intelligence technology include the following aspects as follows:

(1) There is the development of multi-modal data fusion. By utilizing attention mechanisms, multi-modal associations are established for various types of data and anomalies during information system operation, ensuring comprehensive coverage of both structured and unstructured data in system operation. Cross-validation methods are employed to ensure accurate association-based decision-making, thereby enabling comprehensive integration of multi-modal data from the entire system into AI-powered operation and maintenance models to support subsequent intelligent data analysis and processing during operation and maintenance;

(2) Leveraging edge AI drives distributed operation and maintenance of information systems by deploying AI-powered models to local edge devices, enabling direct handling of simple system failures by these models. Complex failures that cannot be resolved by local edge intelligence models are delegated to more powerful intelligent models or technologies in cloud-based systems, eliminating delays in information system failure handling and ensuring timely resolution of simple failures [13];

(3) There is the development of adaptability and self-evolution, which involves comprehensively integrating new failure cases and operation and maintenance experiences in information system operation into knowledge graphs using reinforcement learning models, providing more new reference bases for knowledge graphs, and ensuring dynamic adjustment of model parameters.

Relying on long-term operation and maintenance optimization strategies, self-iteration of information systems is achieved with the support of various AI intelligence technologies, enabling them to adapt to actual business requirements. This further optimizes AI intelligence technology, making it more suitable for subsequent operation and maintenance needs of information systems and supporting the intelligent operation and maintenance and development of information systems.

4. Conclusion

In summary, AI intelligence technology is a novel technology that is highly valued and extensively researched across various modern fields, particularly in the realm of information system operation and maintenance. Reasonably introducing and applying AI intelligence technology to information system operation and maintenance can eliminate various drawbacks of traditional operation and maintenance models, improve the efficiency and quality of information system operation and maintenance, reduce labor costs, and provide intelligent technological support for operation and maintenance work in information systems across various fields. Through the rational optimization and further development of AI intelligence technology, the AI-driven intelligent O&M of information systems will also reach a brand-new level, achieving intelligent, efficient, and cost-effective O&M results.

Disclosure statement

The author declares no conflict of interest.

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