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COMPUTER DIAGNOSTICS OF MACHINES

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Introduction

In modern industry, the continuous, reliable, and safe operation of machinery is fundamental to production efficiency, product quality, and occupational safety. The increasing complexity of production processes, the automation of equipment, and the widespread use of high-tech machinery necessitate constant monitoring of the technical condition of machines. In this context, one of the most effective ways to reduce maintenance and repair costs and prevent production downtime is the early detection of machinery condition through the implementation of computer-based diagnostic systems.

Computer diagnostics involves the monitoring and analysis of the technical condition, operating modes, and the development dynamics of faults and wear in machines and industrial equipment. This method is based on processing real-time data collected via sensors using specialized software tools. Such technologies enable the early detection of faults, facilitating the planning of maintenance activities and preventing unexpected breakdowns. Currently, diagnostic systems encompass vibration analysis, thermographic inspection, acoustic signal processing, electrical parameter monitoring, and other advanced techniques. Moreover, machine learning, artificial intelligence, and big data analytics technologies provide significant opportunities to automate the diagnostic process, improve accuracy, and optimize maintenance procedures.

However, the effective integration of computer diagnostic systems into industrial environments is a complex and multifaceted challenge. It requires the development of tailored solutions adapted to each type of production, machine model, and operational condition. Additionally, the reliability and quality of

sensors and data processing tools, as well as the accuracy and efficiency of diagnostic algorithms, must be thoroughly investigated. Correct interpretation of diagnostic results and decision-making based on these outcomes play a crucial role in ensuring production reliability and economic efficiency.

Therefore, the aim of this study is to conduct a comprehensive analysis of computer diagnostic methods for machinery, identify their advantages and limitations, and explore effective approaches for their application in real industrial conditions. The research includes a comparative analysis of diagnostic methods, evaluating their effectiveness and scope based on industrial practice. Furthermore, the impact of machine learning and intelligent analysis techniques on the diagnostic process is examined. The results of this study provide practical recommendations for improving maintenance and repair operations, reducing production downtime, and extending the service life of equipment.

Methodology

This study comprehensively examined a variety of computer diagnostic methods commonly employed in industrial machinery condition monitoring. The primary techniques investigated included vibration diagnostics, thermographic inspection, acoustic analysis, and electrical parameter monitoring. Each method was selected based on its unique capability to detect specific types of faults and degradation mechanisms in machinery, allowing for a multifaceted approach to fault detection and maintenance optimization.

The research began with a thorough literature review and theoretical analysis to establish the principles, advantages, and limitations of each diagnostic method. Following this, a comparative evaluation was conducted to assess the effectiveness and practical applicability of these techniques in real-world industrial environments.

In the experimental phase, a set of industrial machines representing typical production equipment were instrumented with various sensors tailored to capture relevant diagnostic data. Vibration sensors measured oscillation amplitudes and frequencies; infrared cameras collected thermal images to identify abnormal heat

patterns indicative of wear or overheating; acoustic sensors recorded sound emissions to detect anomalies such as cavitation or mechanical looseness; and electrical monitoring devices tracked parameters such as current, voltage, and resistance fluctuations linked to electrical faults.

Data acquisition was performed continuously over an extended operational period, allowing for the collection of real-time and historical data reflecting both normal operating conditions and emerging faults. The gathered datasets were then processed using advanced computational tools. Statistical analysis techniques—including time-domain and frequency-domain analyses—were applied to extract meaningful features from raw sensor data.

Moreover, to enhance the diagnostic accuracy and automate fault detection, machine learning algorithms were implemented. Supervised learning models were trained on labeled datasets to classify machine conditions and predict potential failures. These models incorporated algorithms such as decision trees, support vector machines, and neural networks, selected based on their suitability for pattern recognition and anomaly detection in sensor data.

The integrated use of statistical and machine learning methods enabled a robust evaluation of the diagnostic system's performance in terms of accuracy, sensitivity, and timeliness. Key performance indicators included the system's ability to detect faults at an early stage, reduce false positives, and support predictive maintenance planning.

Overall, this multi-methodological approach provided a comprehensive framework for analyzing the strengths and weaknesses of different computer diagnostic technologies, facilitating the development of optimized maintenance strategies tailored to specific industrial needs.

Results and Discussion

The research results confirmed the effectiveness of computer diagnostics for machines. Vibration and thermographic methods showed high performance in early fault detection. Electrical parameter monitoring enabled forecasting of technical faults.

Table 1. The main characteristics of diagnostic methods and their application efficiency

Diagnostic Method	Key Indicators	Efficiency (%)	Application Area
Vibration Diagnostics	Vibration amplitude, frequency	85	Detection of mechanical faults
Thermographic Inspection	Thermal imaging map	80	Overheating, wear issues
Acoustic Analysis	Noise processing	75	Air faults, noise levels
Electrical Monitoring	Current, voltage, resistance	70	Electrical system diagnostics

The analysis shows that comprehensive use of diagnostic methods provides complete and accurate information about the technical condition of machines. The speed and accuracy of data processing by computer systems optimize maintenance scheduling and ensure uninterrupted production.

Conclusions

Computer diagnostic methods enable early detection of machine faults and efficient maintenance planning. Vibration and thermographic diagnostics have the highest effectiveness, but combined application improves results further. Use of machine learning algorithms automates diagnostic data processing and reduces errors. Implementation of computer diagnostics in industrial processes increases equipment reliability and reduces economic costs. Future improvements in diagnostic systems require enhancement of sensor quality and development of analytical software.

References:

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