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Innovation of Engineering Enterprise Management mode based on artificial intelligence technology

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ABSTRACT

Engineering Enterprise Management is facing multiple challenges, such as the increase in project complexity, the difficulty of dynamic resource allocation, and the high requirement of decision-making timeliness. The traditional management mode has been difficult to adapt to the rapidly changing market demand. The rapid development of artificial intelligence technology provides new management tools for engineering enterprises, and its advantages in data processing, pattern recognition and independent decision-making, it can effectively optimize the resource allocation, improve the ability of risk prediction and enhance the scientific nature of management decision-making. However, the existing research lacks systematic exploration of the deep integration path of artificial intelligence technology and engineering management process, which restricts the full release of technical potential. Therefore, this paper discusses the innovative application mode of artificial intelligence technology in engineering enterprise management to build a new management system of data-driven, intelligent decision-making and dynamic optimization. It provides theoretical support and practical reference for the digital transformation of engineering enterprises.

KEYWORDS

Artificial Intelligence; engineering management; model innovation; intelligent decision-making; resource allocation

There are many pain points in Engineering Enterprises' project management, such as resource misallocation, out-of-control progress, and lagging decision-making. The traditional management mode relies on human experience, which makes it challenging to deal with the dynamic complexity of large-scale projects. Artificial intelligence technology analyzes massive engineering data through machine learning algorithms, which can accurately predict material loss and schedule risk. Intelligent scheduling system optimizes equipment and manpower allocation in real-time, which significantly improves resource utilization. The self-decision model helps managers to make emergency plans quickly and effectively reduce the loss of engineering change. However, due to the fragmentation of data and the complexity of business logic in engineering scenarios, the application of artificial intelligence technology faces practical obstacles such as poor model adaptability and weak decision-making interpretability. It is of great strategic value to study how to deeply integrate artificial intelligence technology with the engineering management process and build an intelligent management system covering the whole project life cycle to promote the engineering industry's high-quality development.

1 The application of artificial intelligence technology in engineering enterprises

1.1 Data mining and big data analysis

Data mining technology reveals hidden management rules and risk signals by analyzing the massive business data accumulated by engineering enterprises. In project cost management, the system can automatically analyze the data of material consumption, labor cost and construction period in the historical project, identify the abnormal fluctuation pattern and warn of the potential risk of overrun. For example, the nonlinear relationship between pile foundation construction cost and precipitation under certain geological conditions is found by correlation analysis, which can assist in optimizing budget allocation. In supply chain management, multisource data fusion technology integrates supplier quotation, logistics timeliness, quality inspection report and other information to construct a dynamic evaluation model to realize supplier hierarchical management and procurement strategy optimization[1]. For the safety management of the engineering site, the video monitoring data and sensor information can automatically identify the risk behaviors, such as not wearing a helmet and illegal operation, after clustering analysis and trigger real-time early warning. This data-driven management method transforms scattered information into structured knowledge.

1.2 Machine learning and predictive analytics

By building predictive models, Machine Learning Technology empowers engineering enterprises with forward-looking

management capabilities. In the project schedule control, the prediction model based on a long-short-term memory (LSTM) network can analyze the historical duration data and environmental factors and dynamically predict the completion probability of construction nodes. For example, by inputting features such as weather forecasts and records of delays in the arrival of materials, the system can predict the risk of delays in the concrete pouring process two weeks in advance and recommend process adjustments. In terms of quality control, convolutional neural networks(CNN)analyze concrete crack image data to realize automatic classification and cause tracing of defects, and the accuracy is significantly improved compared with traditional manual detection. In cost management, the ensemble learning model integrates multi-dimensional data such as bidding price, market fluctuation and design change to predict the total project cost deviation trend and support dynamic budget adjustment[2]. These predictive abilities shift enterprises from passively dealing with problems to actively preventing risks, significantly reducing the probability of rework and default compensation.

1.3 Autonomous decision-making system and intelligent scheduling

The autonomous decision-making system simulates the decision-making logic of complex engineering scenarios through reinforcement learning algorithms to achieve optimal allocation of resources. In the multi-project parallel management scenario, the system monitors each site's equipment utilization rate, personnel skill matching degree and material inventory in real-time and dynamically generates the optimal scheduling scheme. For example, when the tower crane is used in conflict, the system automatically generates an equipment-sharing plan and compensation scheme according to task priority, equipment transfer cost and time urgency. In the disposal of emergency events, knowledge graph technology is used to associate the historical case base with the emergency plan base and combined with real-time sensor data to generate disposal suggestions. In the scheme of a sudden geological slide in subway construction, the system recommended a collaborative scheme of support reinforcement and personnel evacuation in 5 minutes by integrating structural safety data, emergency material distribution and expert experience database. This intelligent scheduling ability breaks through the response speed and information processing limit of manual decision-making and improves resource utilization efficiency.

2 Management mode innovation of Engineering Enterprises based on artificial intelligence

2.1 Application mode of artificial intelligence in project planning and execution

Deep integration of artificial intelligence technology into the whole process management of engineering project planning and execution. The dynamic planning system optimizes the project schedule using real-time construction data and environmental parameters. In the bridge construction scenario, the system integrates weather data and process logic to automatically adjust the concrete pouring sequence to avoid the impact of rainfall. The progress monitoring module integrates UAV aerial images and sensor data, automatically compares the actual construction progress with the three-dimensional model through image recognition technology, accurately locates the lagging process and triggers the early warning mechanism. The natural language processing engine parses the unstructured text in the project log, automatically identifies risk signals such as subcontractors' abnormal funds and material shortages, and generates response plans by linking the knowledge base. This intelligent planning and execution system breaks through the limitations of traditional static management mode, realizes the paradigm shift from experience-driven to data-driven, and effectively improves the dynamic control ability of complex engineering projects.

2.2 Innovative application of artificial intelligence in resource scheduling and optimization

Intelligent scheduling algorithms reconstruct the resource management logic of Engineering Enterprises to achieve multi-dimensional optimization goals. The equipment scheduling system simulates the interactive logic of construction machinery through a multi-agent collaborative model, integrates the operation radius of the tower crane, the location of the material yard and the process dependence in the construction scene of high-rise buildings, and realizes the automatic generation of equipment movement path planning, significantly reducing the no-load operation time. The Human Resource Allocation Module constructs the skill map of construction workers, dynamically matches the skill characteristics of workers with the task requirements, and adjusts the technical ratio of the support operation team in real-time according to the change of geological conditions in tunnel engineering[3]. Combined with the market price fluctuation prediction model, the supply chain optimization system intelligently determines the procurement window period for steel, concrete, and other materials. It locks the low-price procurement quantity in advance to avoid the risk of cost fluctuation in port construction projects. The carbon footprint tracking algorithm balances economic benefits and environmental constraints in transportation path planning, and municipal engineering cases show that this technology

reduces logistics carbon emissions. These innovative applications promote the transformation of engineering resource management from extensive scheduling to refined configuration.

2.3 Construction and optimization of enterprise intelligent decision support system

The intelligent decision-making system significantly improves the quality of management decision-making through multisource information fusion and simulation deduction. The digital twin platform integrates the BIM model and the Internet of Things data to construct a virtual engineering image. It maps the construction progress and equipment status in real-time in the subway construction project to support managers in conducting immersive decision-making deduction. The risk decision module uses Monte Carlo simulation technology to quantify the risk-benefit ratio of different construction schemes. When the underground cable duct bank project faces a geological catastrophe, the system completes the stability simulation and cost calculation of twelve supporting schemes in ten minutes[4]. The strategic decision engine relies on the industry knowledge map to analyze the policy orientation and market competition situation, intelligently generates business development suggestions, and an engineering group adjusts the overseas market layout to improve the rate of winning the bidding through the engine. The built-in self-learning mechanism of the system continuously collects data on the implementation effect of the decision. It optimizes the parameters of the decision model through the reinforcement learning algorithm, forming a closed-loop evolution mechanism of "Decision-feedback optimization." This intelligent decision support system liberates managers from information overload and enables engineering enterprise management to enter a new era of intelligent decision-making enabled by data.

3 The innovation effect of artificial intelligence in engineering enterprise management

3.1 Optimization of resource allocation and project risk management

Artificial intelligence technology significantly improves engineering enterprises' management efficiency and risk response ability through intelligent resource scheduling and risk pre-judgment mechanisms. The dynamic resource allocation system tracks the equipment operation status, personnel skill distribution and material inventory of the construction site in real-time and generates the optimal allocation scheme based on the algorithm model. Taking the bridge construction as an example, the system automatically plans the moving path of the equipment and the order of material distribution by analyzing the working radius of the tower crane, the real-time location of the concrete vehicle and the priority of each construction node, to minimize the mechanical waiting time and transportation costs. The risk early warning model integrates meteorological data, geological monitoring information and supply chain dynamics to construct a multi-dimensional risk prediction system.

In tunnel engineering, by analyzing the surrounding rock deformation data and historical construction records, the system identifies the potential risk of landslides in advance and recommends a support scheme to avoid construction interruption. Aiming at the problem of supply chain disruption, the algorithm dynamically evaluates suppliers' supply capacity, logistics efficiency and quality stability, intelligently screens alternative suppliers and formulates emergency procurement plans to ensure the continuous supply of key materials.

3.2 Enhancing decision support and prediction accuracy

The decision support system driven by artificial intelligence greatly improves management decisions' scientific and forward-looking nature through data fusion and simulation deduction. A multi-dimensional analysis platform integrating BIM, Internet of Things sensor data and market dynamics to provide a panoramic decision-making basis for managers. In the construction scene of a high-rise building, the system simulates the influence of different construction schemes on the construction period, cost and safety in real time. It shows the advantages and disadvantages of each scheme through the visual interface. It helps managers to choose the optimal path in a short time. The predictive maintenance module establishes the equipment's health condition assessment model by analyzing the mechanical equipment's vibration frequency, temperature change, and other operating parameters. It warns of the potential faults of key components. For example, when the key transmission parts of the tower crane show abnormal wear trends, the system automatically triggers the maintenance work order. It pushes the maintenance plan to avoid the delay in the construction period caused by the sudden failure. The cost control model combines machine learning technology to accurately predict the fluctuation trend of labor, material and management costs in the early stage of the project and assists in formulating flexible budget plans. The decision-making knowledge base continuously collects historical project data and expert experience, realizes intelligent retrieval through natural language processing technology, and provides immediate solution references for emergent problems.

3.3 Realization of intelligent monitoring and quality management

Artificial intelligence technology has reconstructed the engineering quality management system and promoted upgrading quality control from result acceptance to process management and control. The intelligent monitoring system is based on vision recognition and sensor networks and realizes the fine supervision of the construction process. The UAV inspection system captures the image of the construction site through the high-definition camera, uses the image recognition algorithm to compare the design model with the actual progress automatically, and detects quality problems such as structural deviation and steel bar spacing deviation in real time. In the concrete curing stage, the Internet of Things sensor continuously monitors the temperature and humidity of the environment. It automatically adjusts the spray system of the curing shed to ensure that the material strength is stable and up to standard [5]. The quality traceability platform uses blockchain technology to record the material entry inspection, construction process parameters, and quality inspection results, forming a tamper-proof quality file. In highway projects, when cracks or settlement problems occur in any section, the system can be traced back to the specific construction team, material batch and inspection records in minutes, which significantly improves the efficiency of the problem location. The intelligent acceptance system obtains the point cloud data of building entities through 3-D laser scanning. Instead of traditional manual measurement, it automatically generates quality index reports, such as flatness and perpendicularity.

4 Conclusion

This study systematically reveals the internal logic and practice path of management mode innovation driven by artificial intelligence technology in engineering enterprises. Through the deep application of data mining, machine learning and autonomous decision-making systems, engineering enterprises have realized the transformation from empirical decision-making to data-driven intelligent management. In terms of resource allocation optimization, the intelligent scheduling algorithm breaks through the time and space constraints of traditional management and dynamically balances the efficiency of equipment, human resources and materials; at the level of risk management and control, predictive models identify hidden dangers in advance and promote risk management from post-disposal to pre-prevention；in the field of quality control, the intelligent monitoring system realizes the fine control of the whole process, and significantly improves the quality and acceptance efficiency of the project. These innovative practices have solved the long-standing pain points of resource misallocation, decision-making lag and quality control in engineering management and promoted the industry's evolution to digitalization and intelligence.

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