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Autonomous Path Planning for Industrial Omnidirectional AGV Based on Mechatronic Engineering Intelligent Optical Sensors

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Abstract*—With the rapid development of modern industry, the application of automated mechanical and electronic technology is gradually increasing, and the research on automatic path planning is also receiving increasing attention. In this environment of rapid technological progress, rapid growth of the knowledge economy, and fierce competition, industrial intelligence has become an indispensable part of social development. Industrial Automated Guided Vehicle (AGV) has put forward higher requirements for the application of automatic control technology in the planning and research of autonomous path planning. Autonomous path planning with AGV as the service object is currently the most widely used direction in industrial production processes, with the best development prospects and the highest market demand. Optimizing autonomous path planning for AGV is of great significance in promoting the process of industrial modernization and improving industrial production efficiency. In order to solve the problems of low path planning efficiency, excessive reliance on the rich experience and subjective judgment of relevant personnel, and excessive consumption of path planning costs in traditional AGV omnidirectional autonomous path planning, this article attempted to introduce sensor technology to conduct in-depth research on AGV omnidirectional automatic path planning. Based on intelligent optical sensors and combined with ant colony algorithm, the autonomous path planning model for AGV was optimized, and an innovative AGV omnidirectional autonomous path planning model application experiment was conducted in two industrial production enterprises in a certain region. Comparative analysis of experimental data showed that the innovative AGV omnidirectional autonomous path planning model studied in this article had an average improvement of about 17.8% in four evaluation indicators compared to traditional AGV omnidirectional autonomous path planning models.

***Keywords*—Smart machinery; optical sensors; industrial development; autonomous path planning**

I. INTRODUCTION

The development of science and technology is a very complex, lengthy, challenging, and competitive process. In order to adapt to the increasingly competitive modern industrial market, the research on autonomous path planning for systematic omnidirectional AGVs has become the primary task at present. The path planning research that combines the motion transformation of an object or device with the surrounding environment is a flexible design aimed at adapting to external conditions and constraining internal targets. This design idea can achieve response to external environmental stimuli, allowing the target subject to perform autonomous control to complete specified tasks. In the research of automatic path planning, this article has conducted in-depth research, promoting the industrialization process of cities.

Some scholars have conducted experimental analysis on the autonomous path planning of mechanical equipment and summarized some issues that arise in conventional research. They hope to optimize the research direction of autonomous path planning. Gul Faiza conducted in-depth discussions on the purpose of autonomous path planning research and discussed how to find the optimal and shortest path in the autonomous path planning process [1]. Karamuk Mustafa proposed a high-performance autonomous path traction system by studying the optimization direction of AGV autonomous path planning during the interaction between upper software and lower mechanical components [2]. Pantic Michael proposed a novel autonomous path planning scheme to enable machines and equipment to perform motion planning tasks interacting with the environment in complex industrial production activities [3]. Marosan Iosif Adrian optimized the omnidirectional autonomous path planning system for AGVs by studying the use of autonomous mobile platforms in modern industry and combining various sensor systems [4]. In order to improve the path tracking accuracy and stability of AGV vehicles in complex environments, Liu Yaqiu proposed an improved autonomous path control tracking method, which greatly improves the trajectory deviation phenomenon [5]. The above research summarizes the theoretical framework of autonomous path planning.

The optimization of autonomous path planning models is aimed at adapting to more complex industrial production environments and exploring for this purpose. Seder Marija has developed a new omnidirectional AGV autonomous path planning solution based on an open logistics innovation platform for local manufacturing logistics automation systems. It is suitable for complex and difficult transportation tasks, which can improve the control level of local mobile robots and prove its effectiveness [6]. Zhang Jie analyzed and studied the dynamic control of AGV in local industrial production activities. He combined autonomous guidance of mechanical equipment in the Internet of Things with decentralized decision-making methods for path planning and proposed an AGV design scheme using McNumb wheels for autonomous omnidirectional path planning [7]. Quan Yanming explored the balance and motion trajectory of AGV in industrial production activities, and evaluated the safety and reliability of autonomous trajectory planning during AGV cargo transportation by combining different production line scenarios, loading situations, and motion states [8]. Shentu Shuzhan focused on optimizing the autonomous positioning of mobile robots in indoor industrial problems. He integrated hybrid navigation systems and optimized them on the basis of traditional mobile robot autonomous positioning systems [9]. The above research summarizes and analyzes the autonomous planning problem of mechanical equipment in industrial production processes.

In addition, some researchers have considered how to improve the stability and reliability of AGV autonomous path planning in complex industrial production environments. Fragapane Giuseppe analyzed the scheduling application of AGV in local internal logistics business and proposed a central control unit design model that dynamically responds to system state and environmental changes [10]. Moshayedi Ata Jahangir explored the autonomous path planning and design process of AGV robots and the obstacles to their application in modern industry. He conducted a comparative analysis of AGV autonomous path planning systems for different construction schemes [11]. Lin Rui studied the application effects of guided logistics robots for pallet transportation in local areas. Through performance evaluation and analysis of the stability of automated guidance and the reliability of path planning, he determined that the research on machine automation is the future trend of industrial production [12]. The above studies have all analyzed autonomous path planning for automatic transportation machines, but no specific research plan has been proposed.

In order to solve the unstable performance of AGV autonomous path planning applied in traditional industrial production activities, it is difficult to plan the optimal path to complete the task. In the automated transportation process of AGV, there are still many issues such as manual manipulation. This article comprehensively analyzed the traditional AGV autonomous path planning system and summarized its advantages and disadvantages. Combining an intelligent optical sensor system based on mechatronics and intelligent algorithms, an autonomous path planning model for omnidirectional AGV was studied. This model not only fundamentally solves the problems encountered in some traditional AGV autonomous path planning models, but also has good autonomous path planning capabilities in complex industrial production environments and difficult industrial transportation tasks. It also has strong risk response capabilities in the face of unexpected transportation problems in industrial production activities, making contributions to the modernization process of industrial production.

II. TECHNICAL APPLICATION OF INTELLIGENT OPTICAL SENSORS IN ROBOT AUTONOMOUS PATH PLANNING MODEL

In recent years, the highly integrated technology of sensors continues to make breakthroughs and innovations. Optical sensors are widely used in more and more fields, such as intelligent control, path planning, mode transformation, and so on. In the application of autonomous path planning, how to improve the accuracy of robot intelligent identification applications in the path is the main research direction at present. Autonomous path planning requires robots to complete tasks with the most efficient motion trajectory in a complex and dynamic production environment. The best collision free path can be found in known or unknown production environments and relatively efficient path planning can be carried out. It can not only reduce the wear and tear of mechanical equipment during movement, but also improve production and work efficiency in industrial activities, which has extremely high practical significance in the process of industrial modernization [13-14].

In order to conduct better road condition analysis and path planning for complex environments in industrial production activities, intelligent research on autonomous path planning of machinery and equipment is the future trend of industrial development. Industrial production activities often require a large number of industrial raw materials and manufactured products to be transported and transmitted cyclically on the industrial assembly line. Artificial methods are mainly used to analyze road conditions and identify paths in complex industrial production environments, which require subjective judgment and visual identification by professional scholars or experienced staff. It is not possible to enable autonomous learning of transportation equipment, greatly reducing transportation efficiency. It is also difficult to ensure the safety and reliability of the planned transportation path.

With the rapid development of science and technology, complex, diverse, and rapidly changing information abounds in daily life and production work. In order to effectively collect this information and promote the progress of industrial automation and control, intelligent optical sensors have emerged, and are applied on working paths with obstacles, thereby improving the dynamic capture performance of obstacles on the path [15-16]. Based on practical needs, this paper tentatively introduces intelligent optical sensor technology to optimize the design of industrial intelligent production and equipment transportation processes. In industrial transportation operations, optical sensors are used to collect real-time road condition information, and the collected road condition information is fed back to the control center using wireless communication technology. Finally, through learning algorithms, road conditions are analyzed and identified in real time. The autonomous path planning system for robots based on intelligent optical sensors has a higher speed of updating road information and adaptability to complex production environments.

Optical sensors generate varying degrees of electrical signals from different photoelectric effects by collecting information on the intensity of light emitted by the light source on the sensor [17]. This principle enables the conversion of light intensity into quantitative digital data. An autonomous path planning model for intelligent optical sensors is introduced to collect photoelectric signal data in industrial production environments. The collected photoelectric signals are subjected to data analysis and feature extraction before being further optimized for processing. Finally, combined with fuzzy rules, road conditions are intelligently identified. As a result, the process utilizes optical sensors to meet real-time monitoring of road conditions and can plan the optimal path to complete the task, improving the intelligence and accuracy of road condition analysis and path planning on the basis of traditional path planning models.

III. DEVELOPMENT OF AUTONOMOUS PATH PLANNING RESEARCH FOR INDUSTRIAL OMNIDIRECTIONAL AUTOMATED GUIDED VEHICLE

With the extensive practical application of information collection and intelligent control technology in modern science, autonomous robot movement has developed rapidly. Autonomous path planning technology for robots refers to the optimal path planning for robots in complex work environments that does not encounter any collisions from the starting point to the end of the task and meets constraints while following some movement constraints, such as the shortest straight path, the shortest actual time, and the lowest energy consumption. In the construction of modern industry, optimization research on AGV omnidirectional autonomous path planning technology with AGV as the service object is conducive to improving the production efficiency and development process of modern industry.

AGV is mainly used for automatic transportation of raw materials and finished products in industrial production processes. Due to its simple integration, simple programming, and high efficiency, AGV is widely used in industrial manufacturing systems. The working environment of AGVs is mostly under harsh terrain conditions. AGVs need to choose efficient and collision free planning paths as much as possible while completing specified tasks. During transportation, they need higher travel speeds to improve the efficiency of automatic placement and movement of various objects in complex industrial production environments. The optimization of AGV omnidirectional autonomous path planning is an important development direction for modern industries such as discrete manufacturing.

The traditional AGV autonomous path planning method has a low degree of freedom, requiring relevant staff to visually collect road condition information for transportation tasks in complex industrial production environments. Extensive work experience is used to plan paths and set more rigid paths for AGV through programming and other means. The path planned under the traditional AGV autonomous path planning method is difficult to cope with the complex industrial production environment. In the face of sudden and complex road conditions and path obstacles, it is impossible to continue the task set by the program, resulting in a life-and-death lock phenomenon, requiring a large amount of labor costs to detect and correct errors. This does not achieve the original purpose of freeing manpower, reducing costs, and improving production efficiency.

Traditional AGV path planning requires a large amount of manpower and material resources to collect road information in complex industrial production environments. It relies on the professional knowledge of relevant staff with rich work experience and experts to manually plan the AGV transportation path, as well as embedding the program into the AGV core through programming and other methods. The AGV transportation path set in this way is quite rigid. Whenever encountering overly complex road conditions, structures, or sudden obstacles, AGV deadlock occurs, which is not conducive to the conduct of industrial production activities, causing serious consequences such as delayed delivery of production materials at critical moments, leading to the disconnection of the production chain. The optimization of the AGV omnidirectional autonomous path planning model is conducive to promoting the improvement of industrial production efficiency and the advancement of the modernization process. It is necessary to establish evaluation indicators for the AGV omnidirectional autonomous path planning model. Table I shows some evaluation indicators and their behavioral rules.

TABLE I. EVALUATION CRITERIA AND THEIR EVALUATION RULES

Evaluation indicators	**Rules of conduct**
Road condition monitoring	Speed of road condition information collection Number of road condition information collected Road condition monitoring response time
Road conditions prediction	Speed of road information prediction Number of road condition information forecasts Predicted response time for road condition information

In the optimized AGV omnidirectional autonomous path planning model, highly integrated intelligent optical sensor components are combined, greatly enhancing the ability to collect road information in complex industrial production environments. Then, the obtained road condition information is subjected to data calculation and model learning using a deepening learning algorithm to achieve road condition prediction in complex industrial production environments, and has a higher risk response ability in the face of sudden path obstacle problems. The optimal path that meets the constraints is determined on the premise of completing the set tasks, which greatly improves the level of intelligence and automation in modern industrial production activities, and also has a high task completion rate during the progress of AGV transportation tasks. The AGV path planning research structure is shown in Fig. 1.

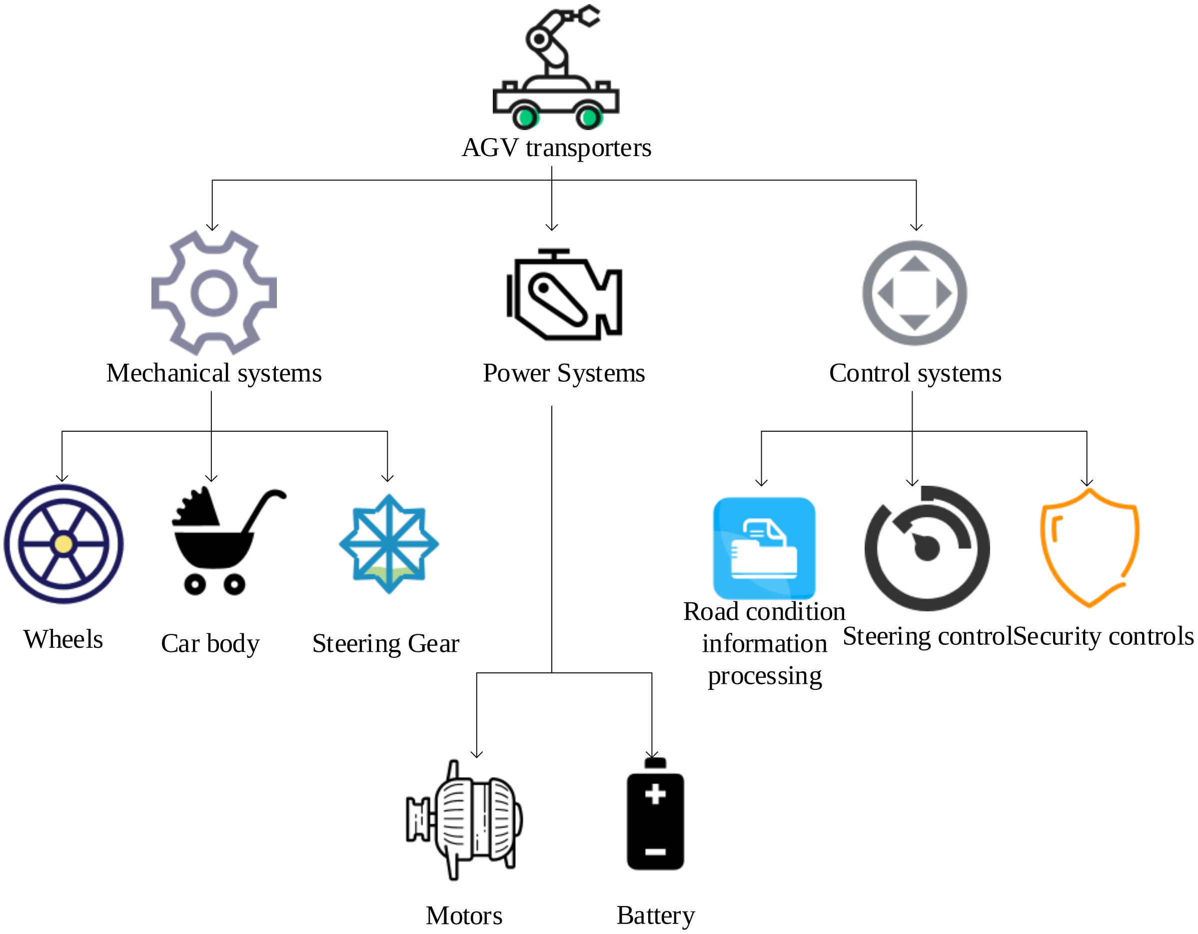

Fig. 1. Structure of the automated guided vehicle path planning study.

IV. APPLICATION OF ANT COLONY ALGORITHM IN AUTOMATED GUIDED VEHICLE OMNIDIRECTIONAL AUTONOMOUS PATH PLANNING

Path planning is one of the important foundations for realizing automatic transportation of AGV, which calculates and classifies the collected data. Then, based on fuzzy rules of data fusion, the optimal path planning is carried out in a complex industrial production environment [18]. In order to overcome the problems of excessive computational cost, difficulty in obtaining optimal solutions, and difficulty in implementing planned paths in complex construction environments, it is possible to solve the path planning problem of a large number of irregular obstacles that hinder AGV from completing industrial transportation tasks in complex industrial production environments. In this paper, an evolutionary ant colony algorithm is used to solve the problem by simulating the process of ants searching for food in nature.

During movement, ant colonies leave a special pheromone secreted on their path. Later, ant colony members make decisions about their direction of travel based on the concentration of pheromones left on the path. The longer the path, the lower the concentration of pheromones. When the ant colony team arrives at the intersection later, they choose a path with a high pheromone concentration to travel, and ultimately find the optimal foraging path through continuous exchange of information throughout the self-organized travel of the entire ant colony. The ant colony algorithm designed based on this principle can play an important role in the AGV omnidirectional autonomous path planning model [19].

Data collection is the premise and foundation of algorithm calculation. A highly integrated intelligent optical sensor emits light beams from a transmitter on a complex industrial production environment path, and a receiver receives the returned light beams. Different photoelectric signals are generated by varying the intensity of the returned light beams, which are used to reflect the specific road condition information of the complex path in the industrial production environment. The collected road condition information is exchanged with the control center through wireless communication technology, and a large number of collected data samples are used as training samples for learning and calculation by ant colony algorithm. The number of samples is Q. $c_{a,b}(a=1,2,\cdots,n_1;b=1,2,\cdots,n_2)$ is the distance between location points a and b in a planar environment, and n_1 and n_2 are two-dimensional vectors corresponding to the planar environment. $j_a(t)$ is the number of environmental samples at position a at time t. $\upsilon_{a,b}(t)$

represents the residual pheromone concentration at time t in path (a,b). The total concentration of pheromones can be calculated by Formula (1).

$$\tilde{\upsilon} = \sum_{a=1}^{n} j_a(t) \tag{1}$$

At the initial moment of the ant colony algorithm calculation, the pheromone concentration content on all paths is quantitatively preset by Formula (2).

$$\upsilon_{a,b}(0) = \zeta \tag{2}$$

Among them, ζ is a constant. During the calculation process, sample $q(q = 1, 2, \cdots, Q)$ determines the next moving direction based on the pheromone concentration on each path. The probability of movement can be calculated by Formula (3).

$$P_{a,b}^{q}(t) = \begin{cases} (\upsilon_{a,b}^{\alpha}(t)\lambda_{a,b}^{\beta}(t)) / (\sum\limits_{e \in M_a^q} (\upsilon_{a,e}^{\alpha}(t)\lambda_{a,e}^{\beta}(t))), & b \in M_a^q \\ 0 & , \quad other \end{cases} \tag{3}$$

Among them, $P_{a,b}^{q}(t)$ represents the probability of a transition from position a to b at time t. $\lambda_{a,b}(t)$ is a local heuristic function for visibility. The parameters α and β represent the influence weights of $\upsilon_{a,b}(t)$ and $\lambda_{a,b}(t)$ on the overall sample transfer probability, respectively. M_a^q represents the feasible area of sample q at position a. As time goes on, the pheromone content on the algorithm's decision path gradually decreases. Formula (4) calculates the pheromone content of the path path when the sample movement completes a cycle of movement after u moments.

$$\upsilon_{a,b}(t+u) = \theta\upsilon_{a,b}(t) + \sum_{q=1}^{Q} \Delta\upsilon_{a,b}^{q} \tag{4}$$

Among them, θ represents the residual degree after the pheromone gradually decreases on a certain path. $\Delta\upsilon_{a,b}^{q}$ represents the amount of pheromone tracks that the sample remains on path (a,b) during this cycle. Finally, through the tradeoff and comparison of pheromone content and concentration, the optimal path planning decision to complete the task is obtained. The above is the calculation process of ant colony algorithm used in the AGV autonomous path planning model in this article. The application of ant colony algorithm makes the AGV omnidirectional autonomous path planning model more efficient. The computational structure of the ant colony algorithm is shown in Fig. 2.

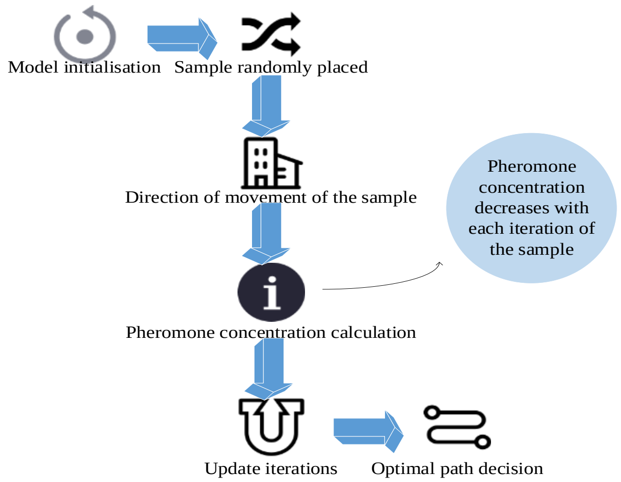

Fig. 2. The computational structure of the ant colony algorithm.

V. APPLICATION EXPERIMENT OF AUTOMATED GUIDED VEHICLE OMNIDIRECTIONAL AUTONOMOUS PATH PLANNING MODEL BASED ON INTELLIGENT OPTICAL SENSORS

With the continuous advancement of industrial modernization, the degree of automation is also gradually improving, and the optimization and upgrading of automatic control systems is the current development trend. The invention of intelligent materials and the development of highly integrated sensor technology pose new challenges to industrial automation. However, in the process of industrial production and transportation, there are still many transportation risks and room for improvement. As an important component of modern industrial development, AGV autonomous path planning and multi-directional parallel control methods are being studied in the direction of high accuracy and reliability.

This article conducts an in-depth analysis of the original AGV omnidirectional autonomous path planning model and identifies the advantages and disadvantages of the traditional AGV omnidirectional automatic path planning model. It proposes solutions to some risks and hidden dangers in the traditional AGV omnidirectional automatic path planning mode. In this paper, based on highly integrated intelligent optical sensors and neural network technology, combined with ant colony algorithm, an omnidirectional autonomous path planning model for AGV was constructed. Laser light was emitted through a transmitter into the industrial production environment, and then the returned refracted light was collected by highly integrated optical sensors. Different light intensities irradiate the photosensitive element to generate different photoelectric signals, and the collected photoelectric signals are exchanged and transmitted by wireless communication technology and the control center. The obtained electrical signal data was injected into the AGV omnidirectional autonomous path planning model as an original sample, and the data was calculated and classified by an ant colony algorithm. Combined with fuzzy rule planning, the optimized path for transportation tasks can be better completed. In this process, real-time monitoring of road information in the industrial production environment was carried out, and risk issues arising on the planned path were promptly investigated and resolved.

With this model structure and data algorithm, an omnidirectional autonomous path planning model for AGV based on intelligent optical sensors was formed. On the basis of inheriting the advantages of traditional AGV path planning models, optimization was conducted to address the shortcomings of traditional AGV path planning that are not intelligent and reliable, improving the monitoring effect of traditional AGV path planning models on complex industrial production environments and their ability to respond to obstacles and risks in planning paths. This AGV omnidirectional autonomous path planning model improves the objectivity and scientificity of traditional AGV path planning models in path planning tasks. It saves a lot of manpower and material costs, and effectively allocates computing resources, which can open up a new direction for the research of AGV omnidirectional automatic path planning. However, it still requires some experiments to conduct in-depth verification.

First, two local industrial production enterprises, A and B, were tested for AGV omnidirectional autonomous path planning applications. During the experiment, the laser probe of the AGV transportation equipment emits laser light on the path in the industrial production environment, and the probe on the AGV transportation equipment collects the light reflected from the path. Intelligent optical sensors collect different photoelectric signals generated by the returned light shining on photosensitive devices, and generate corresponding digital data through analog-to-digital conversion. The obtained large amount of signal data is transmitted to the control center through wireless communication technology, and the large amount of data is calculated and analyzed by the ant colony algorithm as the original sample to build a learning model. Combining fuzzy rules for optimal path planning, an AGV autonomous planning path that can complete transportation tasks with the highest efficiency is obtained. While monitoring the industrial production environment in real time, it can conduct sensitive monitoring of light fluctuations for sudden obstacles appearing on the path, thereby effectively and timely avoiding the risk of sudden obstacles.

The managers and relevant staff of the AGV omnidirectional autonomous path planning model of Enterprise A were surveyed with an application satisfaction questionnaire, and the upper limit of the evaluation index for each satisfaction index was 10. Based on the exponential feedback from the model application satisfaction questionnaire, the application satisfaction evaluations of traditional and innovative AGV omnidirectional autonomous path planning models were analyzed using an exponential comparison, as shown in Fig. 3.

Fig. 3(a) shows the four satisfaction evaluation indicators of Enterprise A under the traditional AGV omnidirectional autonomous path planning model. The four evaluation indicators are road condition monitoring, road condition prediction, transportation time, and risk response. The evaluation index sizes of the four satisfaction evaluation indicators were 6, 5, 4, and 5, respectively. Fig. 3(b) shows the four satisfaction evaluation indicators of Enterprise A under the innovative AGV omnidirectional autonomous path planning model. The evaluation index sizes of the four satisfaction evaluation indicators were 6, 6, 5, and 6, respectively. The innovative AGV omnidirectional autonomous path planning model outperformed the traditional model in terms of the evaluation index of all indicators except the satisfaction evaluation index of road condition monitoring. This indicates that intelligent sensor technology is not omnipotent, and tradition does not mean backwardness. In the process of optimizing the AGV omnidirectional autonomous path planning model, it is necessary to proceed from reality, based on the advantages and disadvantages of tradition, to improve the shortcomings and shortcomings.

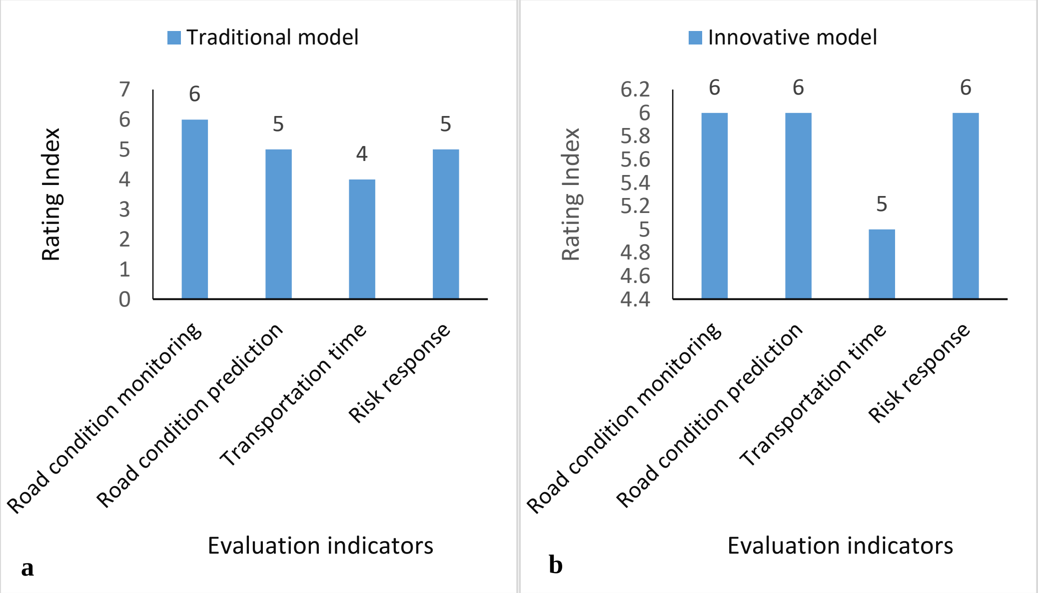

Fig. 3. Satisfactory comparative analysis of the application of traditional and innovative models in Enterprise A, (a). Evaluation of satisfaction with the application of the traditional model in Enterprise A, (b). Evaluation of satisfaction with the application of the innovative model in Enterprise A.

Then, the managers and relevant staff of the AGV omnidirectional autonomous path planning model of Enterprise B were surveyed with an application satisfaction questionnaire. Based on the index feedback from the model application satisfaction questionnaire, an index comparison analysis was conducted on the satisfaction evaluation of the application effect of traditional and innovative AGV omnidirectional autonomous path planning models in Enterprise B. The upper limit of each evaluation index was 10, as shown in Fig. 4.

Fig. 4(a) shows the four satisfaction evaluation indicators for Enterprise B under the traditional AGV omnidirectional autonomous path planning model. The evaluation index sizes for the four satisfaction evaluation indicators, namely, road condition monitoring, road condition prediction, transportation time, and risk response, were respectively 5, 5, 6, and 4. Fig. 4(b) shows the evaluation index sizes of these four satisfaction evaluation indicators for Enterprise B under the innovative AGV omnidirectional autonomous path planning model, which were respectively 6, 6, 7, and 5. As shown in the comparison between Fig. 4(a) and Fig. 4(b), the innovative AGV omnidirectional autonomous path planning model was superior to the traditional AGV omnidirectional autonomous path planning model in terms of four satisfaction evaluation indicators. This indicates that the omnidirectional autonomous path planning model for AGV based on intelligent optical sensors is more efficient than the traditional omnidirectional autonomous path planning model for AGV in terms of overall performance. Electronic information automation technology provides an intelligent and automated development direction for AGV transportation projects in industrial production activities. It improves transportation efficiency in industrial production activities, and contributes to the process of combining industrial automation and information technology.

Finally, this paper analyzed the performance differences between the AGV omnidirectional autonomous path planning model based on intelligent optical sensors and the traditional AGV omnidirectional autonomous path planning model, as shown in Fig. 5.

By summarizing the application performance of traditional and optimized models in Enterprises A and B, the performance differences between traditional and optimized models in four aspects of road condition monitoring, road condition prediction, transportation time, and risk response were analyzed. Fig. 5(a) shows the performance of traditional models in practical applications. In the application process, traditional models have poor performance in coping with risks of sudden problems, and their performance in road condition prediction and transportation time consumption is relatively ordinary. Therefore, there is potential for further optimization in road condition monitoring.

Fig. 5(b) shows the performance of the innovative model in practical applications. From the data shown in the figure, it can be seen that the optimized model has more advantages in performance compared to traditional models. Due to the use of advanced technology and algorithmic processing, innovative models have a more efficient information processing speed, with varying degrees of performance optimization in road condition monitoring, road condition prediction, transportation time, and risk response.

After a comprehensive comparative analysis of the two data, it can be concluded that the innovative AGV omnidirectional autonomous path planning model proposed in this article had an average improvement of about 17.8% in four satisfaction evaluation indicators compared to the traditional AGV omnidirectional autonomous path planning model.

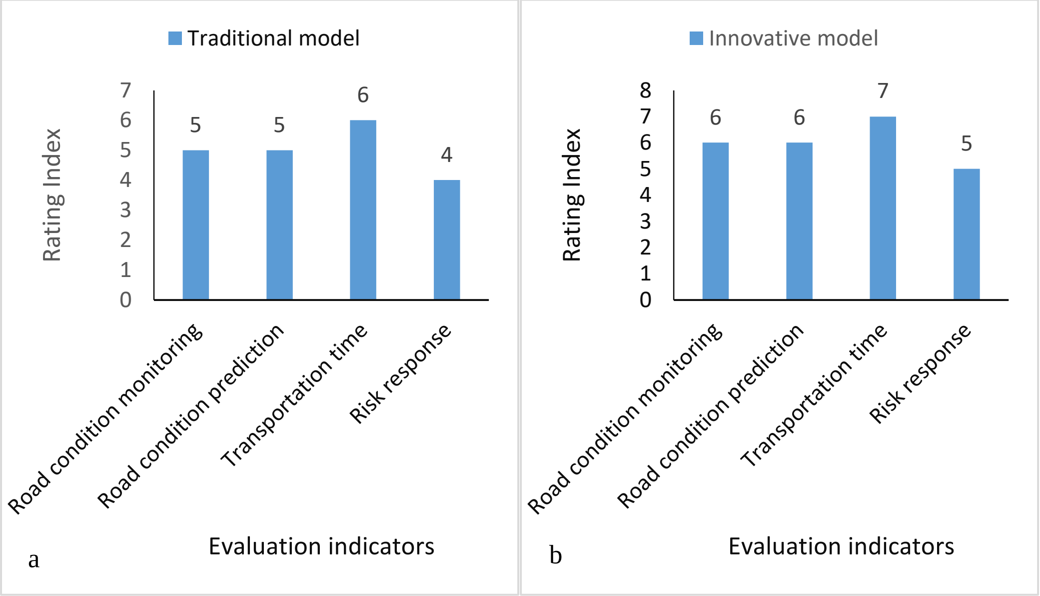

Fig. 4. Satisfactory comparative analysis of the application of traditional and innovative models in Enterprise B; (a). Evaluation of satisfaction with the application of the traditional model in Enterprise B, (b). Evaluation of satisfaction with the application of the innovative model in Enterprise B.

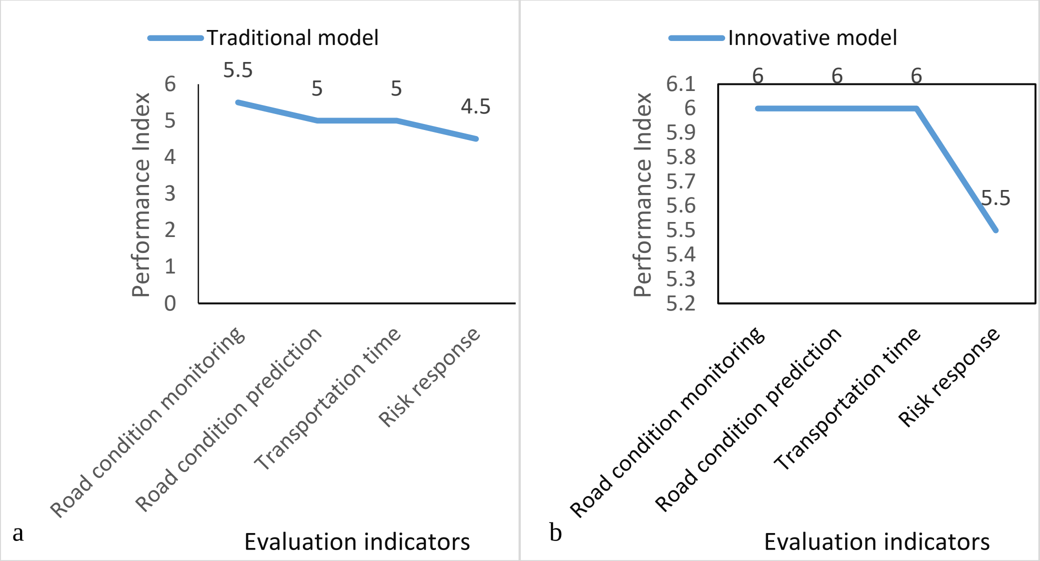

Fig. 5. Comparative analysis of the performance differences between traditional and innovative models, (a). Performance evaluation of traditional model application, (b). Performance evaluation of innovative model application.

VI. CONCLUSION

With the development of modern industry, AGV autonomous path planning technology has become an important field that has attracted much attention. It can not only be used as a new transportation tool for industrial production activities, but also become the most widely used technology carrier for information transmission and processing in future industrial production activities. Although the application of AGV in the field of industrial automated transportation is approaching maturity, there are still many problems, such as complex mechanisms, high costs, and low operating efficiency. With the development and innovation of highly integrated sensor technology, new challenges have been posed to AGV omnidirectional autonomous path planning. In order to solve the problems of high cost in collecting road condition information during the route planning process of traditional AGV autonomous path planning models, rigid route planning for AGV transportation tasks, and untimely response of AGV to unexpected problems arising from planned routes during transportation tasks, based on highly integrated intelligent optical sensors, this paper combines intelligent ant colony algorithm to optimize the AGV omnidirectional autonomous path planning model. In the application process of this model, corresponding countermeasures have been proposed to address the shortcomings and shortcomings of the traditional AGV omnidirectional autonomous path planning model. In the actual industrial production activities, the transportation efficiency of industrial production activities has been improved, and a large amount of manpower and material costs have been saved. At the same time, the complex industrial production environment has been monitored in real time, and sudden obstacles on the AGV transportation path have been risk predicted and timely responded to. Planning a more efficient route on the basis of ensuring the completion of industrial production and transportation tasks has promoted the process of industrial production modernization. This article has conducted model application experiments using this innovative model in two industrial production enterprises in a certain region, and conducted a satisfaction evaluation questionnaire survey on the application effect of intelligent optical sensors in the AGV omnidirectional autonomous path planning model. Based on the analysis of the satisfaction evaluation index of the experimental results, it can be concluded that this AGV omnidirectional autonomous path planning model using intelligent optical sensors has greatly improved the efficiency of transportation tasks in industrial production activities. It is worth affirming that the optimized AGV omnidirectional autonomous path planning model has a higher level of intelligence compared to traditional AGV omnidirectional autonomous path planning models. Traditional models consume a lot of costs to plan paths that are too fixed, making it difficult to specify safer avoidance plans based on road conditions when facing sudden obstacles and emergency risks. The optimization model in this article can save a lot of time and labor costs while ensuring the progress of transportation operations in the face of complex industrial production environments, and its emergency avoidance ability is also more outstanding. However, research on energy consumption and resource integration is not yet complete, and further exploration is needed. On the basis of inheriting the advantages of traditional path planning, this article has optimized some shortcomings and made contributions to the application of advanced technology in modern industrial development. However, further in-depth research is needed to explore the integration of model computing resources and energy consumption, in order to design an efficient model with faster path planning speed and lower energy consumption.

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