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Original Paper

Research on the Countermeasures of Arduino Smart Warehouse Logistics Trolley in Warehouse Logistics

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Abstract

With the rapid development of e-commerce and logistics industries, the efficiency of warehouse logistics systems has become a key factor in corporate competition. This article focuses on the research of an intelligent warehouse logistics vehicle based on the Arduino platform, aiming to improve the automation and intelligence level of warehouse logistics. It discusses the significant role of the Arduino intelligent warehouse logistics vehicle in increasing the penetration rate of intelligent warehousing, improving labor efficiency, meeting the diversity of warehouse logistics needs, and reducing logistics costs. It also focuses on the application of its weighing sensor system in optimizing inventory management schemes. The intelligent warehouse logistics vehicle has the characteristics of simple operation, stable operation, and strong adaptability, and has high practical value and application prospects.

Keywords

Arduino, Warehouse logistics, Logistics vehicle

1. Current Situation of the Development of Warehousing and Logistics

In recent years, with the rapid development of the economy and the continuous improvement of residents' consumption level, the scale of the warehousing and logistics market has continued to expand. According to research, the market size of China's intelligent logistics warehousing industry has increased from 88.29 billion yuan in 2019 to 153.35 billion yuan in 2023, with an average annual compound growth rate of 14.8%. It is predicted that the market size of China's intelligent logistics warehousing industry in 2024 can reach as high as 176.05 billion yuan (China Commerce Industry Research Institute).

The warehousing and logistics industry is currently in a stage of rapid development, with the market scale continuing to grow. Technological innovation is driving the transformation towards intelligence, and green development has become a trend. The trend towards supply chain integration is evident, with a wide range of diverse service areas. However, there are differences in development between regions.

In the future, with the promotion of multiple factors such as globalization, technological innovation, and the rise of e-commerce, the warehousing and logistics industry will usher in broader development prospects.

2. Introduction to Arduino-based Intelligent Storage and Logistics Vehicle

Arduino is a convenient, flexible, and easy-to-use open-source electronic prototyping platform. It includes hardware (various models of Arduino boards) and software (Arduino IDE) (Li Jialei, 2021). Arduino can operate across platforms - it can run on the three major operating systems: Windows, Macintosh OS (Mac OS), and Linux, with minimal limitations (Yan Zifan, 2023); at the same time, this open-source platform does not require much knowledge of microcontrollers or programming, making it simple to learn and easy to operate. As an excellent hardware platform, Arduino has low cost and strong innovation potential.

3. Current Issues of Logistics Trolleys in the Warehousing and Logistics Sector

3.1 The penetration rate of warehousing and logistics trolleys in the existing market is low, and the manual efficiency in warehousing and logistics is relatively low

With the development of technology, intelligent warehouses have emerged, which make full use of advanced information technology and Internet of Things technology to achieve intelligent, automated, and refined warehouse management. Since 2014, traditional forklift enterprises have sought to transform and have successively entered the forklift AGV market. According to data from the CMR Industry Alliance and statistics from the New Strategic Mobile Robot Industry Research Institute, the overseas sales scale of China's AGV enterprises in 2022 was 3.6 billion yuan, a year-on-year increase of 44%, accounting for 19% of the total sales scale (Analysis of the Development Trend of China's AGV Robot Industry in 2023). Overall, the development of forklift AGV manufacturing enterprises in China is uneven. Although more and more enterprises are entering this market, it is not easy to make a difference in the market.

Traditional warehouses, as an indispensable component of the logistics system, have always been responsible for storing and safeguarding goods. However, traditional warehouses currently rely mainly on manual operations and inventory management, with goods warehousing, ex-warehousing, inventory checking, and other operations mainly being completed manually. Manual operations result in slow operation speeds and low accuracy in scanning and recognition, making it difficult to meet the demand for rapid response to market changes.

3.2 The closed-source approach adopted by the AGV vehicle system makes it challenging to fulfill customization demands

Many AGV manufacturers adopt closed-source processing for their AGV scheduling systems and related software to protect their core technologies. For example, Hikrobot, a leading enterprise in the AGV industry, has adopted closed-source measures for its core technologies and scheduling systems to protect

its technological achievements and competitive advantages. Stander, an AGV manufacturer focusing on laser SLAM technology, has also closed-sourced its navigation system and related software to ensure the stability and security of its technology. This can prevent competitors from obtaining its technological secrets through reverse engineering and other means, thus maintaining its market competitive advantage. However, closed-source systems limit users' ability to customize AGV vehicles. If users require specific functionality or performance, they may need to request customization from the manufacturer. This often results in high customization costs, including design fees, development fees, testing fees, etc. In addition, the customization development process may involve complex negotiations and negotiations, further increasing time and money costs.

3.3 Technical issues in loading and unloading weight measurement in warehouse inventory management

According to scholarly research, it has been found that in the current stage, human factors lead to significant waste in the material handling and semi-finished product handling processes, affecting the overall efficiency of the work (Wang Xin, 2019).

Traditional manual management does not fully utilize modern information technology, which may lead to information lag or errors during the loading and unloading process. The record of goods in and out of the warehouse remains in the stage of paper documents or manual processing, lacking digital management methods, and the accuracy of goods information cannot be guaranteed. The update of goods in and out of the warehouse information lags behind, and the status of goods cannot be tracked and traced in real time. Traditional inventory management methods such as electronic spreadsheets are not flexible, and employees cannot access real-time data, which increases the daily workload of inventory management. Delayed records and complex communication lead to low accuracy of inventory information, and inventory is prone to redundancy, resulting in cost waste.

The lack of an effective inventory management system may lead to inventory backlog and chaotic storage of goods in the warehouse. Inventory backlog not only occupies valuable warehouse space, but also increases the difficulty and pressure of loading and unloading operations, which may result in excess inventory or expired goods piling up, and even affect the efficiency of goods delivery.

4. Countermeasures and Applications of Arduino Logistics Trolley in Warehousing and Logistics

4.1 The application of Arduino intelligent storage and logistics vehicles has improved the penetration rate of intelligent storage and the manual efficiency of storage and logistics

The construction and operation of intelligent warehousing systems often require significant capital investment, including warehouse construction, intelligent equipment procurement, system integration, etc. At present, the market share of logistics vehicles is still relatively low, while the Arduino intelligent warehousing logistics vehicle, as a relatively low-cost and high-efficiency solution, can reduce the threshold for enterprises to enter the field of intelligent warehousing. This vehicle integrates an Arduino control board and various sensors to achieve functions such as autonomous navigation, target recognition, and cargo handling, and its relatively low cost enables more enterprises to introduce intelligent

warehousing technology. As a successful case, the Arduino intelligent warehousing logistics vehicle provides technical demonstration and reference for other enterprises. Its successful application proves the feasibility and effectiveness of intelligent warehousing technology, enhancing the confidence and determination of other logistics enterprises to adopt Arduino intelligent warehousing logistics vehicle technology. At the same time, the application of Arduino intelligent warehousing logistics vehicles also promotes the continuous development and improvement of intelligent warehousing technology, providing more possibilities and choices for the popularization of intelligent warehousing.

The application of Arduino intelligent storage and logistics vehicles can improve the manual efficiency of storage and logistics at this stage. Storage and logistics personnel can be liberated from the heavy work of handling and scanning, and focus on higher-level logistics management and optimization work. This not only improves work efficiency, but also enhances employee job satisfaction and happiness (She Zihang, 2024). For example, traditional material scanning methods often rely on manual operation, which is prone to errors. The Arduino intelligent storage and logistics vehicle reduces human intervention through automated scanning and recognition, thereby reducing the error rate. In addition, the basic operations that the Arduino intelligent storage and logistics vehicle can achieve in storage and logistics include automated handling and scanning, helping warehouses conduct real-time monitoring and scheduling

4.2 The open-source program of Arduino intelligent storage and logistics vehicle can meet the diversity of storage and logistics needs and reduce costs

The demand in the warehousing and logistics industry is diverse, with different enterprises, warehouse environments, and operational processes. Therefore, warehousing and logistics vehicles need to have certain adaptability and flexibility to meet the needs of different enterprises. Currently, there are certain limitations in the functionality, performance, and adaptability of warehousing and logistics vehicles on the market. At the same time, the research and development, production, and maintenance costs of a warehousing and logistics vehicle are relatively high, which is a significant investment for many enterprises.

Using Arduino smart storage and logistics vehicles in warehousing and logistics can greatly solve these problems. The Arduino platform is an open-source hardware and software platform, which means users can freely modify and extend programs according to their own needs. This flexibility allows Arduino smart storage and logistics vehicles to adapt to the needs of different warehousing and logistics scenarios. The Arduino platform provides a rich set of library functions and extension modules, which users can use to easily implement various functions such as material recognition, path planning, obstacle avoidance, etc. Enterprises can write customized programs according to the specific needs of warehousing and logistics. For example, for scenarios that require precise scanning and identification of materials, specialized image processing algorithms can be written to improve recognition accuracy. At the same time, through reasonable program design and hardware selection, Arduino smart storage and logistics vehicles can maintain long-term stable operation, meeting the reliability requirements of the warehousing

and logistics industry for equipment.

The open-source nature of the Arduino platform allows users to freely access a wealth of resources and code examples, thereby reducing development costs. Thanks to the comprehensive documentation and active community support provided by the Arduino platform, users can quickly find solutions to any issues they may encounter during use, further reducing maintenance costs.

4.3 Optimizing inventory management scheme for weighing sensor system of Arduino intelligent warehousing and logistics vehicle

In the Arduino logistics vehicle, the HX711 can be connected to various weighing sensors to monitor the weight of goods in real time. Real-time weight monitoring: Through the HX711, the logistics vehicle can obtain real-time weight information of the goods it is carrying and transmit the data to the central control system. This allows the system to update inventory status in a timely manner based on changes in the weight of the goods, avoiding inventory information lag or errors. At the same time, the sensing system of the HX711 can be used for inventory warning. When the inventory level falls below a preset safe inventory level, the system can automatically trigger an alert mechanism to remind management personnel to replenish the inventory in a timely manner. Additionally, the HX711 can help the system monitor changes in the weight of goods and determine whether there are any cases of theft or damage to the goods.

This sensor can provide accurate weight data, which is helpful for accurately tracking the weight changes of inventory items and achieving dynamic monitoring of inventory quantity. Combined with the powerful processing capabilities of Arduino, the sensor can be designed with intelligent algorithms to analyze and process weighing data. For example, through the analysis of historical data, the consumption rate of inventory items can be predicted, so as to replenish or adjust inventory strategies in advance. Furthermore, the weighing data can be transmitted to the cloud server in real time using a Wi-Fi module, enabling remote monitoring and management. In this way, managers can view the inventory status at any time and make timely decisions. Finally, other sensors such as temperature and humidity sensors, as well as RFID readers, can be integrated to build a comprehensive warehouse operation logistics vehicle. These sensors can provide richer inventory information, such as the status and location of items, which helps to further improve the efficiency and accuracy of inventory management.

5. Conclusion

The application of Arduino intelligent warehousing and logistics vehicles in real-world logistics demonstrates its great potential in improving the penetration rate of intelligent warehousing, artificial efficiency of warehousing and logistics, meeting the diversity of warehousing and logistics needs, and reducing costs and weight-based inventory management. Arduino intelligent warehousing and logistics vehicles can accurately identify material information, effectively improving the efficiency and accuracy of warehousing operations. At the same time, the flexibility and scalability of the Arduino open-source platform greatly adapt to the personalized needs of different warehouse environments. In addition, the

optimization of the weighing sensor system and the vehicle storage structure provides powerful technical support for inventory management and precise distribution, ensuring the accuracy and efficiency of logistics operations.

The application of Arduino intelligent warehouse logistics vehicles will improve the intelligence level of logistics operations in the future, injecting new vitality into the transformation and upgrading and sustainable development of the warehouse logistics industry. With the continuous progress of technology and the continuous expansion of application scenarios, Arduino intelligent warehouse logistics vehicles are expected to play an important role in more fields.

Fund Project

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