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Analysis on application prospects of intelligent unmanned card collection Summary

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Abstract: As labor costs rise and logistics volumes expand, unmanned trucks have become the focus of major freight companies. Especially in the development process in recent years, driverless technology has become known to everyone, and with the implementation of driverless driving, people's lives and the face of the city have become completely new, and it has deeply stimulated freight and logistics corporate nerves. This article introduces the intelligent horizontal transportation equipment used in ports, including container automated guided transport vehicles (AGV) , intelligent guided vehicles (IGV) and intelligent network-connected unmanned truck collection (UCT). Both UCT and IGV rely on the new generation of 5G communications and artificial intelligence, which are the future trends in the transformation of automated terminals into intelligent terminals. They conducted a comprehensive analysis of the development prospects of automated driving in ports.

Keywords: Unmanned card collection; Development prospects; Automated terminals.

1. Introduction

With the further intensification of economic globalization and the continuous development of information technology, my country's ports have entered a critical period of digital, intelligent, and green transformation. In the past two years, more and more traditional terminals in China have actively promoted the transformation and upgrading of infrastructure into smart ports. In October 2021, at the commissioning ceremony of Tianjin Port's world's first smart zero-carbon terminal, Mainline Technology delivered the unmanned truck collection "Trunk Port" and the artificial intelligence transport robot (ART) driven by humans and machines together, and tried to integrate the unmanned truck collection From the horizontal transport business of containers in the port to leaving the port, accelerating the march towards a broader high-speed trunk logistics scenario [1,2] , China is currently rapidly developing the intelligent construction of ports represented by automated container terminals.

2. Current status of intelligent container terminals

Autonomous driving technology mainly refers to unmanned container trucks using laser radar SLAM, navigation and positioning systems and multi-sensor fusion positioning technology to achieve autonomous driving in different scenarios. One of the key factors for the practical application of autonomous driving technology includes the complexity of the scenario. The impact of scenarios on the realization of autonomous driving technology is often based on eight factors: simple port traffic signs, low pedestrian interference, low vehicle interference, low static interference, low course complexity, low-speed driving, and complete infrastructure. Comprehensive evaluation is promoted in port scenarios. The feasibility of autonomous driving technology.

2.1. Magnetic permeability (AGV)

Three main forms of port autonomous driving solutions: the first mode is in the magnetic permeability AVG, which requires the configuration of a dedicated magnetic permeability sensor, a dedicated site in the terminal, and the laying of a large number of magnetic nails to facilitate the automatic driving of the AVG. To provide continuous navigation information, the driving area of AVG also needs to be isolated from the external collection cards that collect suitcases at the port [3] . This requires setting up a handover area in the yard to allow AVG to handover containers with external trucks. This model requires high investment in terminal infrastructure, a large demand for funds, and a certain area of the yard as a handover area.

2.2. Intelligent guided straddle carrier (IGV)

With the help of Beidou positioning system, laser radar, cameras and other multi-sensor fusion positioning technologies, independent operation control units such as intelligent guided vehicles (IGV), automatic unlocking stations, and remote-control quay cranes are connected in series, taking the lead in realizing the entire unmanned automated operation system. Control and management, building a stable and efficient unmanned automated control system [3] Since straddle carriers can usually only meet the stacking height of 1 to 3 layers of containers, and China’s container terminals generally have dense storage yards, the straddle carrier solution is very popular in domestic ports. Not much use, with main cases concentrated in European ports .

2.3. Intelligent network-connected unmanned card collection (UCT)

The third mode is to install visual cameras, lidar, millimeter-wave radar and other sensors on traditional container trucks, and equip them with an autonomous driving computing platform to achieve unmanned driving of the container truck. If a large number of traditional terminals and semi-automated terminals that have been put into production in China are to be transformed and upgraded into smart ports, they will adopt the third mode when introducing unmanned driving technology, which is to upgrade the existing traditional container trucks into intelligent network-connected unmanned container trucks (UCT), can minimize the transformation of the existing infrastructure of the terminal, and the upgrade and transformation of traditional container trucks can be carried out in batches and put into use in batches. UCT and traditional manned trucks operate in mixed operations, and manned trucks can be used again. Gradually replace with UCT . This will also have less impact on terminal operations. In addition, a self-driving fleet management system will be developed to provide overall dispatch control for all UCT vehicles. After the traditional container truck is upgraded to UCT, it should have functions such as environmental awareness, high-precision positioning, planning and decision-making, and automatic chassis control. With the use of driverless fleet management systems, high-precision maps, etc., the terminal can be realized as a whole. Unmanned horizontal transportation [4].

At present, self-driving trucks on high-speed trunk lines have begun small-scale trial operations. From the China Intelligent Driving Industry Research Report Fig.1 shown in Figure 1.3, we can see that unmanned trucks at ports have broad market prospects and are expected to be realized by 2025. With massive growth, the market size is expected to exceed 2 billion yuan [5].

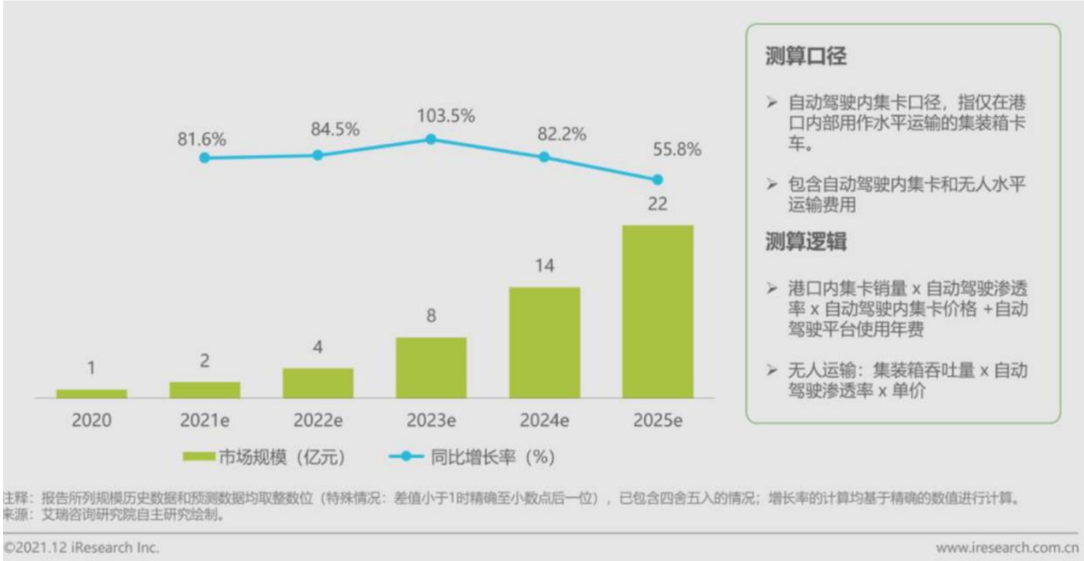

Fig. 1 Two or more references

3. Analysis of Application Prospects of Three Intelligent Container Transport Vehicles

3.1. Continuous coupling of port core operating processes

Compared with fully automated terminals operated by AGV, the TOS systems of traditional terminals are generally less intelligent, and errors in command tasks often occur. At the same time, most of the yard bridge and quay crane equipment of traditional terminals have not been automated. Unable to get device details accurately. In order to solve the above challenges, the integrated port autonomous driving solution not only provides a functional docking solution with the traditional terminal TOS system, but also realizes full-site operations by docking with systems such as intelligent tally, automatic charging piles, and centralized twist lock stations. The collection of elements and function scheduling optimization are closely coupled with the port operation process. During port operations, the positioning accuracy of UCT is required to be high. The port autonomous driving technology using 5G network is extremely susceptible to interference from the GPS signal caused by the metal structure of the container. In addition, factors such as inaccurate manifests and changes in the quay crane operating position cause UCT to face more and more complex challenges during the operation than the traditional AGV mode. By installing scanning equipment on the quayside bridge and combining bicycle vision and laser recognition technology, the positioning and relative position accuracy under the quayside bridge are improved, which meets the precise guidance of UCT matching operation process points.

3.2. Innovation breakthrough path planning strategy logic

In the bicycle adaptation port stage, path planning is determined by UCT, and vehicles do not communicate with each other. Congestions and deadlocks are often encountered at intersections. Compared with traditional AGV path planning, the innovative and breakthrough UCT path planning strategy performs semantic segmentation and obstacle analysis on the surrounding environment by continuously applying for forward coverage areas while driving, calculates the possibility of the path, and generates a path planning algorithm to complete the task. UCT determines the path and time window based on the analysis of continuous points in space and time. When the time and space trajectories converge in the same time window and converge in a specific area, it is predicted to be a congested area. The path planning calculates a new route based on the conditions of the congested area. Or use speed control strategies to avoid congestion, so as to improve traffic efficiency and effectively avoid congestion. In addition, innovative breakthroughs in path planning allow both the bicycle and the platform to take advantage of their own strengths. The platform predicts the spatio-temporal trajectories of multiple vehicles based on the vehicle's planned instantaneous speed and issues path planning; however, due to factors such as individual vehicle differences, load, and road conditions, the path issued by the platform is a recommended reference path, and UCT needs to be based on the posture and allowable deviation of the vehicle.

Make independent path planning and realize independent decisions such as turning, changing lanes, and avoiding obstacles.

3.3. Dual-line collaborative energy management and job scheduling

Regardless of AGV or UCT, most of them are driven by electricity. There are battery life issues during the operation process, which requires dual-line coordination between vehicle energy management and operation scheduling. When the AGV is running, it will perform opportunistic charging scheduling management in the card exchange area. UCT also inherits the rotation charging strategy, dispatching vehicles in batches to complete charging, taking turns to work online and offline to charge, balancing the relationship between vehicle power and charging facility resources. Because UCT charging facilities are much smaller than AGVs, in order to ensure the continuity of production operations, port autonomous driving innovation uses a charging scheduling strategy for UCTs based on stepped time or power differentiation. The specific strategy mainly refers to the alternate charging of operating UCTs through intelligent algorithms to avoid the simultaneous consumption of power of participating UCTs , resulting in a collective low power situation at the same time period, causing charging peaks and putting pressure on the use of charging pile facility resources. In addition, the problem of idle charging piles due to too few UCT charging at the same time period needs to be considered simultaneously, because the simultaneous consumption of UCT power participating in the operation will also lead to the formation of the next charging peak. In order to solve the problems that may arise from the above types of charging dispatch, port autonomous driving uses linkage between multiple systems to implement optimized and variable energy management plans based on information interconnection, transforming production factors from a single energy consumption unit to an integrated charging and storage unit. The management system improves operating efficiency while achieving effective energy management.

3.4. Develop a hybrid strategy that empowers open scenarios

Autonomous driving in ports is surpassing the scenario limitations of AGVs. It has been put into trial operation in many open traditional terminals at home and abroad, and is beginning to try to enter the stage of large-scale commercial application. For open terminal scenarios, the problem of mixed row strategies needs to be solved. For example, when the UCT is transferred out of the yard, because the vehicle body has not left the yard, the camera and sensor are completely obscured by the containers in the yard. This is one of the most dangerous scenarios in mixed traffic development. The port's autonomous driving technology has pioneered the use of manned truck driving habits. For example, when leaving the yard, the UCT will look out at a certain distance from the yard entrance to stop and wait for N seconds, and then proceed after judging that there is no safety risk at the intersection. In the decision-making of autonomous driving in mixed scenarios, it is necessary to take into account the centralized dispatching capabilities of the strong platform and the intelligent planning capabilities of single vehicles. In the decision-making process, it is necessary to establish an application and approval mechanism between the platform and the bicycle to ensure that when the behaviors between the two interact, each subject can make favorable decisions based on the information they have and their understanding of their own capabilities. Under the mixed traffic strategy, port autonomous driving not only maximizes the characteristics and participation of bicycle intelligence, but also closely cooperates with the upper platform system. The vehicle relies on its own perception algorithm and control algorithm to drive in the area. The cloud also ensures the safety of the vehicle and draws on the strengths of the cloud and the vehicle.

4. Conclusion

There are hundreds of ports, large and small, distributed along my country's coasts and inland rivers. For a long time, these ports have played an extremely important role in my country's economic construction. With the rapid development of information technology, some traditional ports have been unable to adapt to the requirements of the development situation. In the process of transformation and upgrading of traditional ports, the application of driverless technology is both an important link and a difficult issue. In actual work, unmanned horizontal transportation at the terminal can be achieved by upgrading the original traditional container trucks at the terminal to UCT and using an autonomous fleet management system. This upgrading and transformation model can help traditional ports realize the transformation and upgrading of smart ports at a lower cost.

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