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Based on the RoboMaster Tournament Lower Steering Wheel Chassis Wheelset Design

ShangHai, Jiang Shuzhe[1], ShangHai, Ma Qihua[2], ShangHai, Hu Sujingjie[3], ShangHai, Chen Siyan[4]

[1] *School of Mechanical and Automotive Engineering, ShangHai, Jiang Shuzhe*
[2] *School of Mechanical and Automotive Engineering, ShangHai, Ma Qihua*
[3] *School of Mechanical and Automotive Engineering, ShangHai, Hu Sujingjie*
[4] *School of Mechanical and Automotive Engineering, ShangHai, Chen Siyan*

Abstract
This paper focuses on the in-depth research of steering-wheel robots based on RoboMaster. Through methods such as literature research, experimental studies, and case analysis, it elaborates on the working principles, key technologies, and comparative advantages of steering-wheel robots over other types. The design processes for mechanical structures, hardware systems, and software algorithms are detailed. Domestic research achievements are cited and analyzed, including specific steering-wheel suspension structure designs and the application of efficient path-tracking algorithms. Combining excellent cases, the paper explores application strategies in RoboMaster competitions, covering tactical coordination, scenario adaptation, and solutions to practical challenges. Additionally, it discusses technological development trends, extended application prospects, and facing challenges. The research results demonstrate that steering-wheel robots exhibit excellent performance and broad prospects in competitions and potential application fields through unique designs, providing new ideas and references for the development of robotics technology.

Keywords: *RoboMaster , hardware systems.*

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I. INTRODUCTION

1.1 Background and Significance of the Study

With the rapid development of science and technology, the application of robotics technology in various fields is becoming more and more extensive, from industrial production to daily life, from health care to education and entertainment, robots are profoundly changing our way of life and mode of work. Among the many directions of robotics research, RoboMaster-based steering wheel robot has become one of the research hotspots in the field of robotics due to its unique performance and wide application prospects.

RoboMaster, a robotics competition for university students around the world, has attracted the participation of many colleges and research institutions since its inception in 2015. In the competition, participating teams need to utilize multidisciplinary knowledge of mechanical design, electronic circuits, control algorithms, artificial intelligence and other disciplines to design and build robots capable of autonomously completing tasks in complex environments. This not only provides a platform for university students to demonstrate their creative and practical abilities, but also promotes the development and innovation of robotics.

As an important model in the RoboMaster competition, the steering wheel chassis robot has a high degree of maneuverability and flexibility. Through the rotation and steering of the steering wheel, it can realize a variety of complex motions, such as in-situ rotation and lateral movement, and it shows excellent motion performance in narrow spaces and complex terrains. This unique movement ability makes the rudder wheel robot has a broad application prospect in the field of logistics and warehousing, industrial handling, security inspection and so on.

In the field of logistics and warehousing, with the rapid development of the e-commerce industry, the efficiency and accuracy of logistics and distribution has become the key to competition. Tiller robots can navigate autonomously in the warehouse, quickly and accurately complete the handling and storage of goods, greatly improving the efficiency and automation level of logistics and warehousing. In the field of industrial handling, wheel robots can be flexible shuttle in the factory floor, handling a variety of raw materials and parts, reducing the labor intensity of workers, improve production efficiency. In the field of security inspection, steering wheel robots can be in dangerous environments or personnel difficult to reach the area for inspection, timely detection of potential safety hazards, to protect the safety of production and life[1]。

In addition, the study of RoboMaster-based steering wheel robot is of great academic value. The research and development of the steering wheel robot involves the knowledge of many disciplines, such as mechanical design, electronic circuits, control algorithms, artificial intelligence and so on. Through the research of the steering wheel robot, it can promote the cross-fertilization of these disciplines and promote the development of related theories and technologies. At the same time, the autonomous navigation and motion control of steering wheel robots in complex environments are also difficult to study in the field of robotics. The research and solution of these problems can help to improve the robot's intelligence level and autonomous decision-making ability, and lay the foundation for the development of future robots.

In summary, the RoboMaster-based steering wheel robot has an important research background and significance. Through the research and development of the steering wheel robot, it can promote the development and innovation of robotics technology, expand the application fields of robots, improve the production efficiency and quality of life, and also provide new ideas and methods for the research of related disciplines.

1.2 The Current Status of Domestic and International Research

In the research field of steering wheel robot, scholars and research teams at home and abroad have carried out in-depth explorations centering on key aspects such as structural design, motion control, etc., and achieved a series of remarkable results, but at the same time, they are also faced with a number of urgent problems to be solved.

In terms of structural design, foreign countries have been at the forefront of technology. Some U.S. research institutions have developed a new composite material steering wheel robot structure, significantly reducing the weight of the robot itself, in order to protect the strength at the same time, improve the efficiency of energy utilization, so that its endurance can be enhanced to meet the needs of long-time operations. Japan is in the rudder wheel of the refined design of the outstanding performance, through the optimization of the internal mechanical structure of the rudder wheel, reduce the mechanical wear and tear of the rudder wheel steering, prolonging the service life of the rudder wheel, and improve the stability and reliability of the robot as a whole. However, these advanced designs are often accompanied by high manufacturing costs, which limits their large-scale application.

There are also unique innovations in domestic structural design. With the intelligent transformation of the domestic manufacturing industry and the expansion of the consumer market, there are a lot of heavy-duty AGV technology needs, some domestic university team research team through the optimization of the load structure to increase the anti-collision device and vibration-damping drive assembly of the technical route, put forward a heavy-duty AGV design solutions[2]It is useful for the upgrading and transformation of the equipment manufacturing industry of heavy industry and warehousing logistics.

Generally speaking, rich results have been achieved in the research of steering wheel robots at home and abroad, but there are still deficiencies in the cost control and high-end manufacturing of structural design, optimization of motion control algorithms and hardware adaptation, which need to be further researched and improved..

1.3 Objectives and Content of the Study

The aim of this study is to design and realize a high-performance wheelset for RoboMaster's steering wheel robot with excellent motion performance and task execution capability in complex environments, with the following specific research objectives:

Objective 1: To design a compact, high-strength and lightweight wheel mechanical structure for steering wheel robots to meet the motion requirements in different scenarios, and at the same time to reduce the manufacturing cost and improve the cost-effectiveness of the robots.

Objective 2: Through experimental testing and data analysis, verify the performance indexes of the steering wheel robot, continuously optimize the design, and improve the overall performance of the robot.

In order to achieve the above research objectives, the study will be organized around the following elements:

The overall structure of the steering wheel robot is designed, including the selection and layout of the steering wheel, motor, suspension and other components. Using the principle of mechanical design and knowledge of engineering mechanics, strength analysis and optimization of key components are carried out to ensure the stability and reliability of the robot structure. At the same time, new materials and manufacturing processes are considered to reduce the weight of the robot and improve its energy utilization efficiency.

II. ROBOMASTER-BASED WHEEL SET DESIGN FOR STEERING WHEEL ROBOTS

2.1 Design of Mechanical Structures

The results obtained are as discussed below

2.1.1 A Brief Description of the Chassis Structure

The chassis is the basic support component of the steering wheel robot, and its design directly affects the stability and motion performance of the robot. This design adopts the aluminum alloy frame structure as shown in Figure 1, aluminum alloy has the advantages of low density, high strength, corrosion resistance, etc., in order to ensure the structural strength of the chassis at the same time, effectively reduce the overall weight of the robot, and improve the efficiency of energy use.

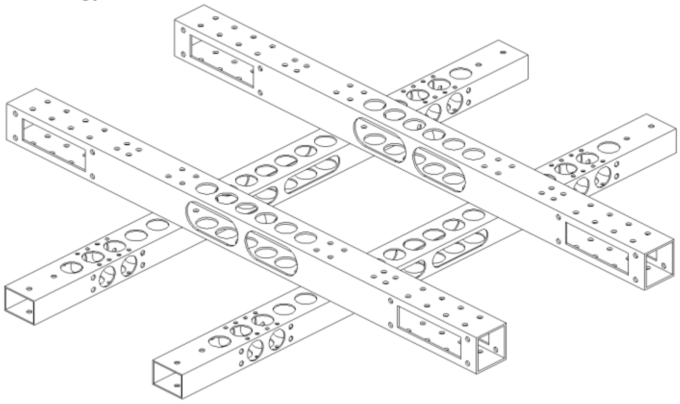

Figure 1 Chassis aluminum alloy frame

The chassis layout adopts the four-wheel distribution form as shown in Fig. 2, and the four rudder wheels are mounted on the four corners of the chassis as shown in Fig. 3, forming a stable support structure. This layout makes the force on the robot more uniform in the process of movement, and it can better adapt to different terrain and working conditions. In the center of the chassis, the robot's core control unit, power module and other key electronic equipment are installed. Concentrating these important components in the center of the chassis helps to lower the robot's center of gravity and improve its driving stability, and also facilitates wiring and signal transmission to reduce electromagnetic interference.

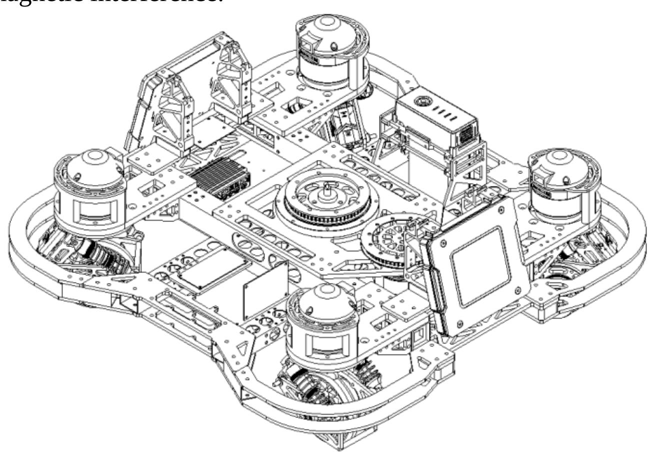

Fig 2 Overall structure of the steering wheel chassis

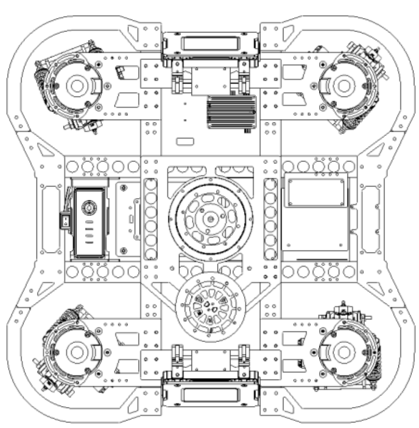

Fig 3 Schematic diagram of the chassis wheelset location

2.1.2. Tiller Wheel Block Mechanism

The steering wheel mechanism is the key component of the steering wheel robot to realize omnidirectional movement, and its mechanical structure directly determines the steering and driving performance of the robot. The steering wheel in this design is mainly composed of drive motors, suspension system, steering motors, wheel hub and other parts.

The drive motor adopts M3508 brushless DC motor as shown in Fig. 4, which has the advantages of high efficiency, long service life and high reliability, and can provide stable driving force for the rudder wheel. In order to meet the needs of the rudder wheel wheelset reliable and strong, high terrain passability, the M3508 brushless DC motor was modified, the original M3508 motor only has a mounting surface, prone to stress concentration, so the motor end face modification as shown in Fig. 5, from the original one mounting surface backward derivation, and then made an end face to dispersal of the wheelset stress.

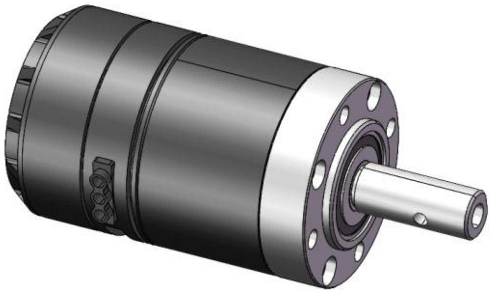

Fig 4 Schematic diagram of retrofitted M3508 motor

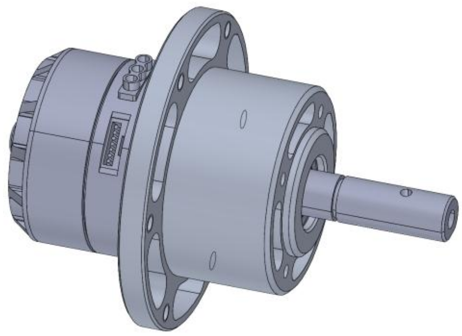

Fig 5 Schematic diagram of the original M3508 motor

In order to prevent the robot from being damaged by the bumps caused by the complex road and to prolong its service life, a suspension system is added to the wheel set design. The energy absorbing device in the suspension system is a rigid compression spring as shown in Fig. 6, and the rigid spring is connected to the connecting rod as shown in Fig. 7, which can transfer all the impact force to the compression spring when the robot passes through the complicated road sections, and thus it can absorb the impact force and protect the overall structure of the robot better in the complicated road sections.

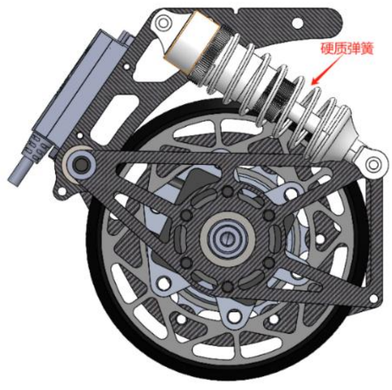

Figure 6 Schematic diagram of suspension linkage structure

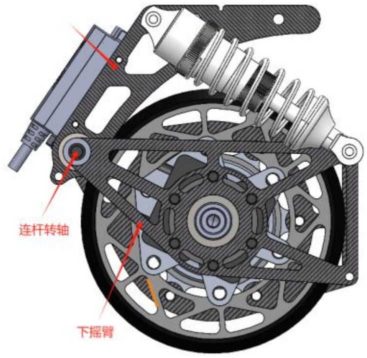

Fig7 Schematic diagram of suspension compression springs

The steering motor adopts GM6020 brushless DC motor, which is responsible for controlling the steering angle of the rudder wheel. The steering motor steering rudder as shown in Figure 8 is connected to the GM6020 motor with an absolute encoder, which can realize the precise steering control of the rudder wheel. In the rudder plate design, the use of 7075 aluminum alloy material processing, with KA025XP0 point contact bearings, so as to ensure that the steering wheel steering accuracy, stability, but also to meet the needs of high strength.

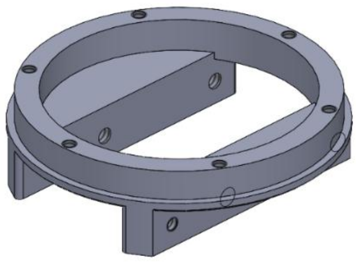

Fig 8 Rudder Schematic

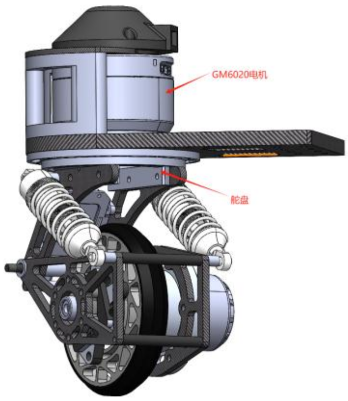

Fig 9 Schematic diagram of the overall structure of the suspension

The wheel hub is made of aluminum alloy, which is precision machined and has the characteristics of high strength and light weight. On the periphery of the wheel hub, rubber tires are mounted. The tires are selected taking into account the robot's usage scenarios and movement requirements, and have good wear resistance, grip and shock absorption. The tread design of the tires is optimized to provide sufficient friction under different ground conditions to ensure the stability and safety of the robot during driving.

In the overall structural design of the steering wheel, the installation and matching accuracy between the components are fully considered. Through high-precision machining and assembly process, it ensures the close connection and high coaxiality between the drive motor, steering motor, reducer, hub and tire, which reduces the energy loss and vibration in the process of mechanical transmission and improves the overall performance of the rudder wheel.

III. CONCLUSIONS AND OUTLOOK

In the industrial field, the helm wheel robot is expected to become the core logistics equipment of the smart factory. With the advancement of Industry 4.0 and smart manufacturing, factories are demanding more and more automation, intelligence and flexibility in material handling. With its flexible movement ability and accurate positioning control, the steering wheel robot can efficiently complete the handling tasks of raw materials, semi-finished products and finished products in the factory floor. In automobile manufacturing factories, steering wheel robots can accurately transport parts to each station according to the real-time demand of the production line, realizing the seamless connection of the production line and improving production efficiency and quality. Compared with the traditional fixed-track logistics equipment, the steering wheel robot does not need to lay a complex track, according to the factory layout and production process changes in the rapid adjustment of the transportation path, has a higher degree of flexibility and adaptability, and greatly reduces the cost of factory renovation and operating costs.

In the service field, the application of wheel robot is also broad prospects. In hotels, restaurants and other places, steering wheel robots can undertake food delivery, delivery and other services. Its flexible mobility enables it to travel freely in narrow corridors and crowded restaurants, accurately delivering items to guests, improving service efficiency and reducing the labor intensity of staff. In the medical field, steering wheel robot can be used for drug delivery, medical equipment transportation and other work, reducing the time investment of medical staff in non-medical work, so that they can focus more on the treatment and care of patients. At the same time, steering wheel robots can also play a role in hospital disinfection, cleaning and other work, through the preset path and tasks, to achieve automated cleaning operations, reducing the risk of hospital infection.

Education is also one of the important application directions of the steering wheel robot. Tiller robots can be used as teaching tools in robotics education programs and science and technology innovation activities. Students can learn mechanical design, electronic circuitry, control algorithms and other multidisciplinary knowledge through the design, programming and operation of steering wheel robots, and develop innovative thinking and practical skills. In science and technology museums, museums and other popular science venues, steering wheel robots can be used as interactive exhibits, through the display of its unique performance and intelligent control capabilities, to attract the interest of the audience, popularize the scientific knowledge of robotics, and stimulate the public's love of science and technology and the spirit of exploration. In addition, with the development of online education, the steering wheel robot can also be combined with virtual reality (VR), augmented reality (AR) technology to provide students with a more vivid and intuitive learning experience, breaking the time and space constraints, and realize remote interactive teaching.

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