Design and Research of Omni-directional Moving AGV

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Abstract. Omni-directional mobile AGV can operate flexibly in a narrow space, which can replace heavy and dangerous labour to a greater extent and improve labour productivity. In this paper, the steering wheel integrated with walking and steering functions is taken as the driving unit, and the main research contents include: through digital structure design, the chassis structure and electrical control system of omnidirectional AGV are designed. Experiments show that the design realizes flexible operation of zero turning radius and 360-degree omnidirectional movement in narrow space, and meets the requirements of robot handling operation in complex environment.

1. Introduction
Omni-directional mobile AGV (Automated Guided Vehicle) is used for stacking and unstacking, also known as omni-directional mobile robot. It is an intelligent technical equipment integrating mechanical structure, computer control, sensing technology, artificial intelligence and other disciplines. It can be integrated into any section of the production line to realize the operations of fast product acquisition, handling, packing, stacking and unstacking. Omni-directional mobile robot occupies a small space, so long as it is placed in a suitable position, it can be responsible for stacking operations of multiple production lines at the same time, and for different loads, stacking operations of different loads can be realized only by adjusting relevant control parameters, and its intelligent properties make the work simple and efficient. In this paper, the kinematics and dynamics model of steering wheel-driven omnidirectional mobile handling robot is studied to establish the motion control model and control algorithm to realize flexible operation of zero turning radius in narrow space and meet the requirements of robot handling operation in complex environment.

2. Overall Design of Moving AGV
AGV cars are also called unmanned transport vehicles, automatic guided vehicles and transport robots. It refers to a transport vehicle equipped with electromagnetic or optical, radar laser and other automatic guiding devices, capable of traveling along a specified guiding path, with safety protection and various load shifting functions. It can be operated automatically through battery storage without human control. Generally, its route and behavior can be controlled through a scheduling system, or its route can be set up through an electromagnetic track. The AGV walking system consists of a control panel, a guide sensor, a direction potentiometer, a status indicator lamp, an obstacle avoidance sensor, a photoelectric control signal sensor, a driving unit, a guide magnetic strip and a power supply. The composition structure is shown in Figure 1.
In this design, the overall structural design parameters of the AGV are designed according to the requirements of the AGV's working environment, working contents and working properties, as shown in Table 1.

**Table 1. Design parameter table of AGV.**

| Projects                          | Parameter                   | Remarks                          |
|-----------------------------------|-----------------------------|----------------------------------|
| Overall dimensions (mm)           | 2500×1800×600               |                                  |
| Steering mode                     | Omnidirectional steering    | Can realize in situ steering     |
| Number of steering wheels         | 2                           | Horizontal steering wheel         |
| Steering wheel power (Kw)         | 4                           |                                  |
| Number of angle wheels            | 2                           |                                  |
| Load mass (kg)                    | 3000                        |                                  |
| Readiness quality (kg)            | 1500                        | Including battery                |
| Full load maximum speed (m/s)     | 0.5                         |                                  |
| Control mode                      | Manual remote control, automatic |                                  |
| Protection grades                 | IP454                       |                                  |
| Suspension mode                   | Drum damper                 |                                  |
| Battery                           | Lithium iron phosphate      |                                  |
| Voltage (v)                       | 48                          |                                  |
| Battery capacity (A.h)            | 270                         |                                  |
| Duration (h)                      | 8                           |                                  |

3. **Body structure design**

The car body is the basic part of AGV, the installation foundation of other assembly components, and also one of the main components in motion. The main conditions considered in the design are: (1) the strength and rigidity of the car body must be designed on the premise of meeting the requirements of the car when carrying and accelerating. (2) Reduce the weight of the car body as much as possible so as to increase the effective bearing weight; The premise must be under the condition that the car body has enough rigidity. (3) Try to reduce the center of gravity of the car body so as to improve the anti-rollover capability of the whole car and ensure better and stable operation of the car.
3.1. Driving Device
The driving device is the executive part of AGV to realize automatic guidance control. The main ways are differential drive and steering wheel drive. Latent AGV mostly uses differential drive, which was introduced from Japan by a group of private enterprises that developed AGV earlier in China. At present, Japan's AGV basically uses differential structure. AGV in Europe and the United States has a variety of driving modes, with steering wheel driving as the main driving mode. The steering wheel structure integrates walking traction function and steering function, and has a high integration level. It can load and pull heavy goods up to more than 10 tons. Figure 2 is a structure of a steering wheel driving mode integrated with walking and steering.

![Figure 2. Drive structure of steering wheel drive unit](image)

The driving device consists of wheels, speed reducer, brake, driving motor and speed controller, which is a device to control the normal operation of AGV. AGV can be divided into differential AGV, double steering wheel AGV and single steering wheel AGV according to different driving modes. The number of wheels on the AGV trolley site and the layout of driving wheels, driven wheels and universal auxiliary wheels will directly affect the driving performance of the trolley, such as acceleration performance, deceleration performance, maximum and minimum speed and stability.

![Figure 3. Differential wheel](image)

The subject study is based on the design of the chassis structure of the AGV driven by the steering wheel, and what we are hanging is the AGV driven by the double steering wheel. The AGV studied in the subject study is the double steering wheel AGV, but its gear train structure is shown in Figure 3. Its driving and steering are distributed at two symmetrical corners of the vehicle, and the driving and steering actions are controlled by the driving motor and the steering motor respectively. The driving wheel and the universal wheel are respectively located at the two sides of the front part of the trolley.
The universal wheel only plays a supporting and auxiliary role and has no influence on the motion characteristics and driving performance of the trolley.

### 3.2. Body Chassis

The chassis of the car body is shown in Figure 4.

![Figure 4. AGV body structure](image1)

Figure 4. AGV body structure
(1. Load platform, 2. Driven wheel, 3. Shock absorber, 4. Bearing group 1, 5. Shaft, 6. Bearing group 2, 7. Front wheel connection group, 8. Steering wheel, 9. Rear wheel connection group)

The AGV body structure is a four-wheel structure, which comprises a load platform, a driven wheel, a shock absorber, a bearing group 1, a shaft, a bearing group 2, a front wheel connecting group and a steering wheel, wherein the steering wheel and the driven wheel are respectively connected to the front wheel connecting group by bolts; The bearing group 1 is connected to the front wheel connecting group by bolts, the bearing group 2 is connected to the load platform by bolts, the shaft passes through the bearing group 1 and the bearing group 2 at the same time, and the front wheel connecting group and the load platform are connected into a whole; One end of the symmetrical shock absorber is fixed on the front wheel connecting group, and the other end is fixed on the load platform. The other side of the load platform is rigidly connected with another group of driven wheels and steering wheels respectively through a rear wheel connecting group, as shown in Figure 5.

![Figure 5. Exploded car body](image2)

Figure 5. Exploded car body

According to the AGV with the structure, when two wheels with uneven ground and rigid connection land on the ground, the front wheel connection group can rotate in an appropriate amount around the shaft, so that the driven wheel and the steering wheel land at the same time, four wheels can always land at the same time, the stability and carrying capacity of the AGV are improved, the abrasion of parts is reduced, and the service life of the AGV is prolonged.

### 4. Design of Electrical Control System

The electrical control system mainly consists of a main controller, a configuration screen, a wireless remote control module, a safety protection module, a walking motor A, a walking motor B, a steering motor A and a steering motor B which are controlled based on a CAN bus. The principle block diagram of the electrical control system is shown in Figure 6, in which arrows indicate the direction of information transmission.
The main controller of the electrical control system design adopts the mainstream 32-bit MCU processor based on ARM kernel, which can meet the motion control function requirements of the controller system. The configuration screen carries out man-machine interaction, which can display and prompt the current AGV operation status, whether there is alarm, parameter setting, etc. The wireless remote control module receives a remote control command of a near-field wireless remote controller. The safety protection module adopts contact airbag and non-contact laser radar for safety protection to ensure the safe operation of omnidirectional AGV. The steering wheel motor driver adopts dedicated CAN bus digital communication control motor driver to realize digital control of two drive motors and two steering motors.

In view of the particularity of the omnidirectional AGV function, we have designed and developed a special main controller. As shown in Figure 7, the minimum system circuit of the main controller is composed of STM32F103CT6, which includes voltage stabilizing and power filtering circuits, reset circuits, crystal oscillator circuits, and program startup mode selection circuits.

Figure 6. system principle block diagram
As shown in Figure 8, the MAX232 interface circuit can convert TTL signals into RS232 signals to realize the digital communication function between the main controller and the configuration screen.

As shown in Figure 9, the signal input circuit uses optocoupler isolation to realize the safety isolation of input signals and voltage signal conversion. Through this circuit, we can collect key information and state information of safety protection module and transmit them to the main controller to realize mode selection and safety protection.

Figure 8. MAX232 interface circuit

Figure 9. Signal Input Circuit

Figure 10 are CAN bus conversion circuits. Digital communication between the main controller and other peripheral CAN bus devices can be realized through the TJA1050 conversion chip.
5. Mobile Platform Test
As shown in Figure 11, we tested the omnidirectional AGV in a common industrial factory building with a load of 2 tons. During the test, the omnidirectional AGV designed by us completed remote control starting and stopping, steering in any direction from front to back, left to right, in situ, emergency braking and other movements, and achieved the expected goals in terms of carrying capacity, speed, operation accuracy, zero turning radius and so on.

6. Conclusion
The aim of this paper is to study the omni-directional movement technology of robot based on steering wheel drive, design the structure of the robot chassis and the motion control system, and through practical tests, the results show that the robot with independent control of two steering wheels has better omni-directional movement performance, better vertical and horizontal straight movement and in-situ steering functions, and can meet the technical requirements of omni-directional movement.

7. References
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