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Design of an Intelligent Logistics Sorting Cart

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***Abstract*—The logistics sorting car mainly consists of a QR code recognition layer and a motion control layer. The QR code recognition layer is composed of Raspberry Pi 3b+, USB camera, 4G module, and laser sensor ranging module; The motion control layer consists of mega2560, 3 L298N motor drive boards, and 5 motors. The small car is controlled through Raspberry Pi programming, with a QR code recognition layer such as the 4G module responsible for logistics item recognition and signal transmission. The small car assembly robot arm is responsible for grasping the goods, and the motion control layer can achieve path planning and complete the transportation of logistics items.**

***Keywords*—Path planning; 4G module; Raspberry pie; Mechanical arm;**

I. INTRODUCTION

With the advancement of technology and the rise of online shopping, the logistics industry has ushered in spring. Countless goods need to be classified and transported every day. If manual handling is used, not only is it difficult to improve efficiency, but it also requires significant costs. In the logistics industry, especially in the logistics sorting area within logistics stations, intelligent sorting carts will become the best choice for industrial upgrading. This project designs a logistics sorting cart based on Raspberry Pi, which can use cameras to judge the surrounding environment, avoid obstacles, plan transportation routes, intelligently identify logistics items that need to be handled, and carry out precise transportation. Logistics sorting carts can replace most manual operations with relatively low costs, requiring only a small number of management personnel to achieve efficient logistics sorting, which can significantly improve the company's economic benefits and competitiveness. Therefore, intelligent logistics vehicles have revolutionary significance for logistics companies and even the entire logistics industry.

II. OVERALL SYSTEM DESIGN

The logistics sorting car mainly consists of a QR code recognition layer and a motion control layer. The QR code recognition layer is composed of Raspberry Pi 3b+, USB camera, 4G module, and laser sensor ranging module. The motion control layer consists of mega2560, 3 L298N motor drive boards, and 5 motors. The motors are directly powered by lithium batteries, while mega2560 is powered by lithium batteries through LM7805 voltage stabilizing chips to provide linear DC voltage stabilizing power to the system.

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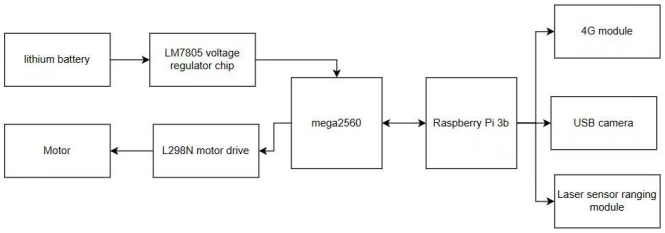

Figure 1 Overall System Design Diagram

III. SYSTEM HARDWARE DESIGN

A. Control system module

In this project, the chip is the most core component of the logistics sorting car. The main control chip connects the QR code recognition module and the motion module, responsible for receiving signals transmitted by the QR code module and controlling the motion module. The Raspberry Pi 3B+uses a 64 bit 1.4GHz quad core CPU, and compared to the 3B version, the 3B+uses faster Gigabit Ethernet. The output and input interfaces for videos, images, etc. required for this project design can be supported by Raspberry Pi 3B+, and it comes with 4 USB interfaces for easy external connection of relevant instruments or components. Overall, Raspberry Pi 3B+is an ideal main control chip in the design of this project

The control platform of the chassis adopts the Arduino driver board as the core. Ardunio is an open-source electronic tool, and the open-source library files in the Arduino IDE can be directly called, making it easy to get started and flexible. The MEGA2560 is compatible with the Arduino development core processor Atmega2560, and has 54 digital input/output ports (15 of which can be used as PWM outputs), 16 analog inputs, a 16MHz crystal oscillator, a USB port, a power socket, an ICSP interface, and a reset button [1]. Raspberry Pi can be connected to it using a USB data cable, transmit signals, issue commands, and then control the motor drive.

B. Motor drive module

The motor is driven by two L298N motor drive boards, which can simultaneously drive four DC motors. The single circuit has a high power of 7A, and the optocoupler isolates the input signal with undervoltage protection, ensuring stability and reliability. The+5V pin on the driver board can be connected to 5V or 3.3V to provide power for the signal end. ENA1 and ENA2 are the motor enable ends and can be connected to PWM on the MEGA2560 driver board to adjust the motor speed. The connection circuit diagram is shown in Figure 2.

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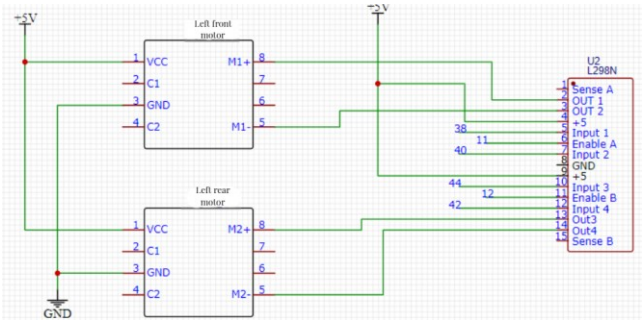

Figure 2 Motor Drive Circuit Diagram

C. 4G module

The 4G module is a wireless module based on 4G networks for wireless transmission and data exchange with remote public network servers. It transmits data to the base station through the 4G frequency band specified for remote data transmission. Generally, 4G modules support multiple protocol connections. The 4G module integrates RF, baseband, etc. on the same PCB board, and can be installed in a car to achieve wireless signal reception, transmission, and baseband signal processing between the car and the base station. The software connects to the base station through 4GLTE network, achieving functions such as dial-up networking and data transmission.

For the control of the small car, combined with the actual situation of the express delivery room environment, we have chosen QUECTELEC20CEHDLG as the communication module. This module adopts LTE3GPPRel.11 technology, combined with the 4G network communication transmission speed. The LTE3GPPRel.11 technology we have chosen can meet our needs. Under this technology, the maximum downlink speed of the logistics sorting car is 150Mbps, and the maximum uplink speed is 50Mbps. At the same time, it is compatible with the EC20R2.1 MiniPCIe-C module on the packaging and can be backward compatible with existing EDGE and 4G/GPRS networks, ensuring normal operation even in remote areas with poor network signals [2]. Through the 4G module, the car can achieve scanning and recognition of QR codes.

D. Laser sensor ranging obstacle avoidance module

The basic principle of LiDAR ranging is to first send out the laser signal, pass through the optical system, and reach the target object. The receiving module receives the reflected laser echo signal from the target object, which is processed and enters the detection system [3]. Finally, the distance information of the target object is obtained. Lidar not only overcomes the disadvantages of millimeter wave radar being easily affected by electromagnetic interference and mutual influence between radars, but also has the advantages of energy concentration, high sensitivity and resolution. In addition, LiDAR has strong anti-interference ability and is not affected by the intensity of sunlight. It can achieve 24-hour uninterrupted work, greatly reducing the cost of logistics sorting and improving work efficiency.

This logistics sorting car is based on Shanghai Jiao Tong University and is equipped with a multiline LiDAR on the roof as an environmental sensing device. A single line LiDAR is installed at the front of the car to ensure that the car can detect obstacles in different positions and identify them. The use of multiline LiDAR can also accurately detect the terrain on surrounding roads, preventing small cars from bumping and damaging fragile goods due to harsh road conditions.

VelodyneVLP-16 has the advantages of low power consumption, high-speed data transmission, stable operating temperature range, and is compact and lightweight, making it very suitable for application scenarios such as robot navigation, map construction, and surveying. This car adopts the VelodyneVLP-16 LiDAR ranging module, which consists of a scanning disk, motor driver, Lidar head, and camera synchronizer. Its electrical parameters are as follows: VelodyneVLP-16 is a small low-cost LiDAR with the following electrical parameters: operating voltage range of 10-24VDC; The average power consumption is 7.5W; The maximum power consumption is 9W; The data interface is an Ethernet interface, supporting 100BASE-T Ethernet. Its data transmission rate is 10,20or25hertz (configurable for multiple data transmission rates); The working temperature range is -10°C to+70°C; The storage temperature range is -40° C~+85°C, suitable for indoor working conditions. Its mechanical dimensions are 103mmx72mm (diameter x height), and its weight is 830g.

The workflow is as follows: the alternating laser emitter emits 16 laser beams, which are reflected back into its receiver when they come into contact with obstacles. Subsequently, after the receiver captures the reflected signal, the hardware of VLP-16 will generate a data packet containing relevant laser transmitter and receiver information. After analyzing and processing the obtained data packets, three-dimensional point cloud data can be generated. The point cloud data is transmitted to the computer via Ethernet through the Lidar head, and further processing by subsequent algorithms can achieve obstacle avoidance for small cars.

E. Visual module

This car uses Raspberry Pi High Quality Camera as the "eye" of the car. Raspberry Pi High Quality Camera is a professional high-definition camera that supports Raspberry Pi environments. It is equipped with a 1/1.8-inch SonyIMX477R image sensor, capable of up to 12.3MP for taking and recording as needed, and supports multiple image formats. It can be used with various lenses, such as variable focus lenses, fisheye lenses, etc., making it very suitable for work such as QR code scanning. By using this camera, not only can the courier QR code be accurately recognized, but the image data output by the sensor can also be analyzed and processed, helping the sorting cart distinguish obstacles and goods.

F. Mechanical arm

The logistics sorting robot plays a crucial role in the handling process, with its robotic arm and gripping actions. In the entire movement space of the robotic arm, it needs to have X-axis, Y-axis, Z-axis, and its own rotational motion. Therefore, it can be known that its degree of freedom is 4, and it requires effective control by four servos [4]. In order to accurately grasp different types of express delivery or logistics, this car is equipped with a four degree of freedom robotic arm, and a vacuum suction cup and gripper are installed at the end of the robotic arm. Its body has three degrees of freedom, and the end effector has one degree of freedom. The robotic arm has five joints, with

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joints 1, 2, 3, and 4 corresponding to four degrees of freedom. The five joints control the opening and closing of the gripper without changing the position of the end effector. Clamps can handle large logistics items, while vacuum suction cups are used to adsorb small valuable or fragile items through air pumps.

In terms of robotic arm control, a combination of upper and lower computers can be used for control. Raspberry Pi is used as the upper computer for deep learning processing, and STM32 is used as the lower computer for controlling the movement of the robotic arm. The data is collected by the camera or sensor connected to the upper computer, and the results of the robotic arm's movement are fed back to the upper computer. The upper computer adjusts and controls the entire process based on the specific situation of the robotic arm's execution and the data transmitted by the sensor, thus achieving closed-loop control of the entire process. For example, for the servo motor that controls the rotation of the robotic claw and the gripping of the robotic claw, the information feedback from the upper computer can be used for control, making the robotic arm more intelligent and efficient as a whole [5].

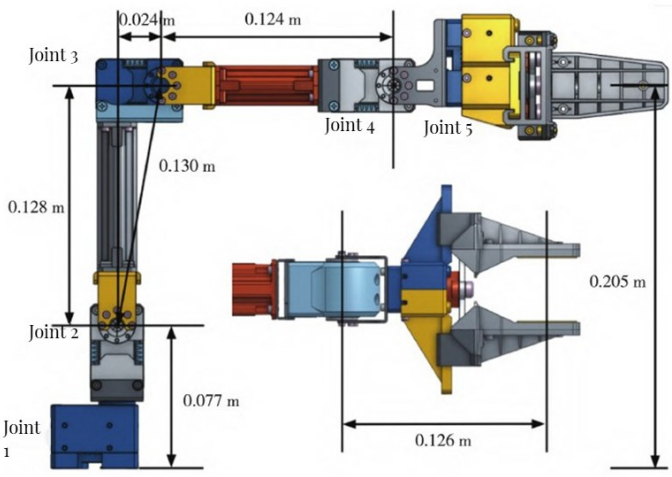

Figure 3 Mechanical Arm Structure Diagram

IV. SYSTEM SOFTWARE DESIGN

The corresponding programs for the control system module, motor drive module, 4G module, laser sensor ranging and obstacle avoidance module, vision module, and robotic arm control are programmed in Python language on Raspberry Pi, and simulation and simulation are completed.

The QR code collection consists of two parts: a car camera and a driver program that reads the camera image. It is mainly used to collect the QR code of the route and transmit it to the Raspberry Pi, which is then analyzed and processed by the image processing algorithm in the computer vision library OpenCV.

The system software design flowchart of the car is shown in Figure 4.

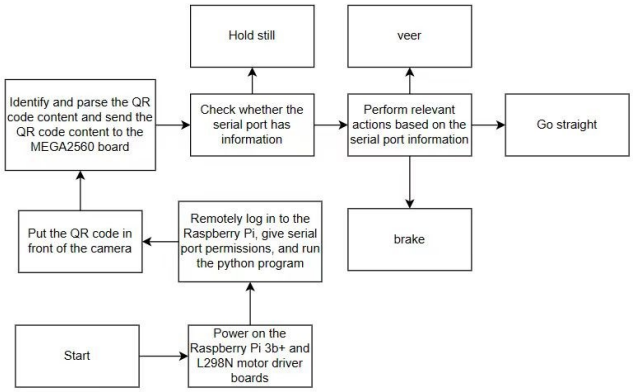

Figure 4 System Software Flowchart

V. SYSTEM INNOVATION

(1) The car adopts a four degree of freedom robotic arm and is equipped with vacuum suction cups and grippers on the end processor, making it easy to adapt to various logistics items.

(2) The car adopts 4G technology, achieving remote control, which can greatly reduce labor costs and liberate labor.

(3) The overall cost of a small car is low, but it is easy to control and stable, which can greatly improve work efficiency.

VI. CONCLUSIONS

This article designs a logistics sorting cart based on Raspberry Pi. This car has functions such as path planning, QR code recognition, and remote control, which can achieve precise grasping and transportatio n,making it easy to control and use. Through the ranging obstacle avoidance module and the robotic arm module, precise grasping can be achieved, and with the help of the path planning function of the car, it is easy to quickly grasp logistics items and transport them to the designated location. In addition ,the car adopts 4G network communication technoly, which can achieve signal transmission and stable control in the vast majority of areas. The car is also equipped with a Raspberry Pi High Quality Camera camera with high accuracy, which can ensure the accuracy of logistics item identification and the safetyof transportation process.

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