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# *Design and Implementation of Tour Guide Robot for Red Education Base*

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***Keywords:*** Red education; Tour guide robot; Internet of Things; STM32; ROS

***Abstract:*** This article focuses on the development of red tourism and the construction of red education bases, and designs a tour guide robot that combines with the Internet of Things for guiding and promoting red education bases. The motion control part of this design is completed by STM32, and the control system adopts the ROS (Robot Operating System) framework, achieving functions such as map construction, path planning, navigation, obstacle avoidance, and voice guidance. The robot also implements the Internet of Things to improve human-machine interaction and user experience.

## 1. Introduction

Since the 21st century, red tourism has developed rapidly. This rapid development is thanks to its strong function in educating the history of the Communist Party of China and the strong support of government policies. Red tourism has innovatively integrated party history education into tourism, innovating in space, philosophy, technology, and form, making this educational method that combines education with pleasure popular among the masses and party members and cadres [1]. Therefore, in the current urgent need to strengthen red education, we will carry out intelligent red tourism services that combine red tourism and artificial intelligence technology, forming strong technical and theoretical support for the integration and development of modern technology and tourism [2]. Utilizing artificial intelligence technology for digital resource development can deepen tourists' perception and understanding of historical culture, enhance their cultural experience, enhance the attractiveness of red cultural bases, promote the development of red tourism using artificial intelligence technology, and enhance people's interest in party history, which is conducive to the learning and inheritance of red culture. In addition, the tour guide industry, due to its high entry threshold and long talent cultivation cycle, is basically in a state of oversupply. In this situation, tour guide robots can effectively alleviate the current situation. This article aims to design and implement a red education base tour guide robot system based on robot technology, providing new ideas and methods for the development of red tourism industry and the application of robot technology in the tourism field [3].

## 2. Overall system design

As shown in Figure 1, the system design of this design is divided into interaction layer, functional layer, and physical layer.

In the interaction layer, Jetson nano serves as the host and the virtual machine on the PC serves as the slave. The host and slave can be connected through WiFi or the ROS Bridge program in ROS can be placed in the same local area network, enabling the Internet of Things. Additionally, a PC can be used to remotely control the host for easy monitoring. At the same time, the robot positioning and map construction in this design can be presented using the Rviz visualization tool, and the system can be controlled through a screen, with various human-machine interaction methods.

At the functional level, the system uses ROS functional packages to achieve communication between various nodes, drive each module, and implement SLAM algorithms, path planning, and other related functions.

At the physical layer, data acquisition from sensors and the use of various peripherals are achieved through controllers, as well as motion control of robots.

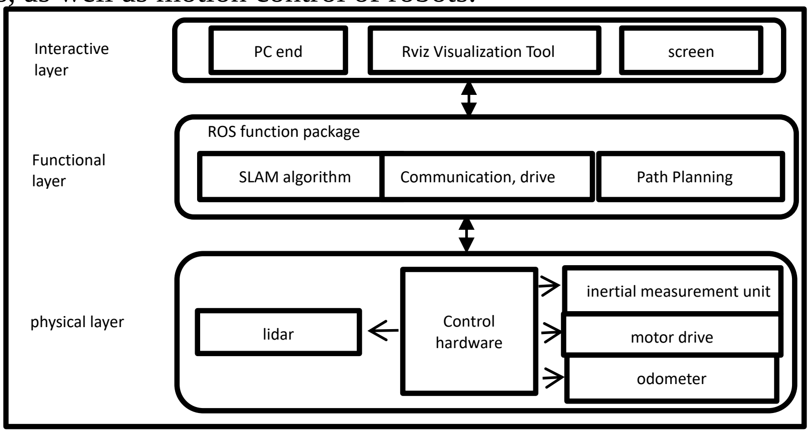


Figure 1: Overall system architecture diagram

## 3. Hardware solution design

### 3.1 Robot motion chassis

This design adopts a McNumb four wheel chassis, as shown in Figure 2. Thanks to the special mechanical structure of Mecanum wheel, the McNamm wheel trolley can move in all directions. Omnidirectional movement refers to the ability of a moving mechanism to move in any direction from its current position on a two-dimensional plane, which includes three degrees of freedom: lateral, longitudinal, and rotational. It is precisely because of the omnidirectional mobility of the wheat wheel chassis that it can efficiently move in narrow spaces, with excellent mobility and flexibility [4-5], which is very suitable for mobile robots to achieve map building, navigation and other functions.

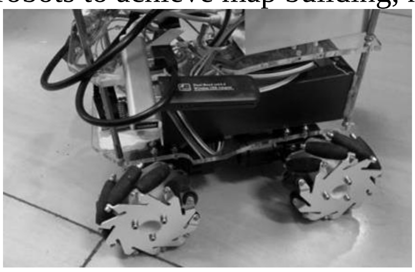

Figure 2: Robot Mecanum wheel chassis

## 3.2 Main control module

The motion master adopts the STM32F1 series microcontroller. STM32 can achieve motion control of the robot by controlling its motor driver [6]. By controlling the speed and direction of the motor through PWM signals, the robot can move forward, backward, left, and right. At the same time, STM32 can also achieve position and speed control of the robot through encoder feedback, ensuring the motion accuracy and stability of the robot.

The main controller adopts a Jetson nano processor, which can achieve robot control, navigation, obstacle avoidance and other functions through the ROS framework. ROS is an open-source robot operating system that adopts modular design, which can improve the scalability and reusability of robots. Make robot functions easier to implement.

## 3.3 Inertial measurement unit

The inertial measurement unit (IMU) sensor is needed in the ROS navigation system. In the ROS robot system, the IMU sensor is integrated into the STM32 controller in this design, and the STM32 controller collects IMU data and sends it to the ROS for data processing. This design uses the MPU6050 as the inertial measurement unit, which is a digital motion processor integrated with three-axis accelerometer and three-axis gyroscope. It can measure the acceleration and angular velocity of objects [7], and transmit the data to the controller STM32 through the I2C bus for data reading, so as to obtain the robot's attitude.

## 3.4 Lidar

The most important sensor required for the laser SLAM technology used in this design is the LiDAR. Lidar can obtain the position and distance information of objects in the environment by emitting a laser beam and receiving reflected light, thereby constructing a point cloud map of the environment. This design uses the SLAM algorithm to process LiDAR data and collaborate with other sensors to construct and locate the robot's map in an unknown environment, thereby achieving the robot's navigation function.

In this design, the Raytheon Intelligent N10 LiDAR is used, which uses serial communication and can perform 360 °omnidirectional laser scanning. It can be used indoors and outdoors, using the TOF ranging principle. The measurement radius of white objects can reach 25m, and the radius of black objects can reach 11m. In ROS, tools such as rviz and command line can be used to visualize and analyze radar data. The laser radar scanning effect of the robot in this design is shown in Figure 3.

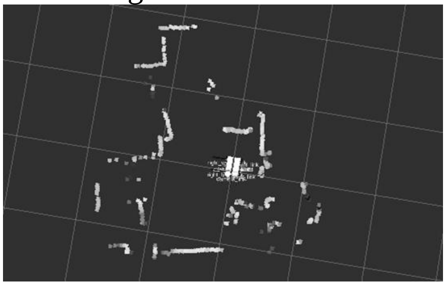

Figure 3: Lidar scanning image

## 3.5 Voice module

In terms of human-computer interaction hardware, this design uses a speech synthesis broadcast module, which integrates XFS5152CE. XFS5152CE is a highly integrated speech synthesis chip that can achieve Chinese and English speech synthesis, and supports mixed reading of Chinese and English. By setting the module through I2C communication and following the specified frame, the operation is convenient and fast. There are three types of interfaces on the module: pin arrangement, PH2.0, and crocodile clip, which have strong scalability. In Jetson nano, it is necessary to write a Python script file to start the hardware. And as a robot tour guide, being able to speak Mandarin fluently is also a necessary skill. When users visit the red exhibition hall, robots can provide voice guidance according to their needs.

## 4. Software solution design

### 4.1 STM32 end

ROS is an operating system running on Jetson Nano, which requires data such as IMU and odometer for robot mapping and navigation. In theory, Jetson Nano can directly connect and collect data from these sensors. However, due to STM32 being able to complete these tasks well, and having a hardware encoder interface, STM32 is more convenient for robots to measure speed. Therefore, this design uses STM32 to collect data from encoders and IMUs, complete PID control of the motor, and then exchange sensor data and control instructions with Jetson Nano through a serial port. Robots can move in multiple directions based on the control commands of ROS. ROS mainly sends speed commands in the X, Y, and Z directions, and the car can move and adjust speed according to the commands issued by ROS.

The STM32 end needs to execute the motion command sent by ROS. The software code flow is shown in Figure 4. Firstly, confirm whether there is a motion command sent by ROS on serial port 3. If so, perform PID control on the motor to control the robot's motion. Then, the angular velocity and acceleration data of the gyroscope MPU6050 are obtained, and the encoder data is continuously obtained through timer interrupts to calculate the robot's motion speed and serve as an odometer. The data is then displayed on an OLED screen for convenient monitoring of the robot's status. Finally, the obtained gyroscope data and the motion speeds of the robot in the X, Y, and Z directions should be sent to the ROS for map construction and navigation functions.

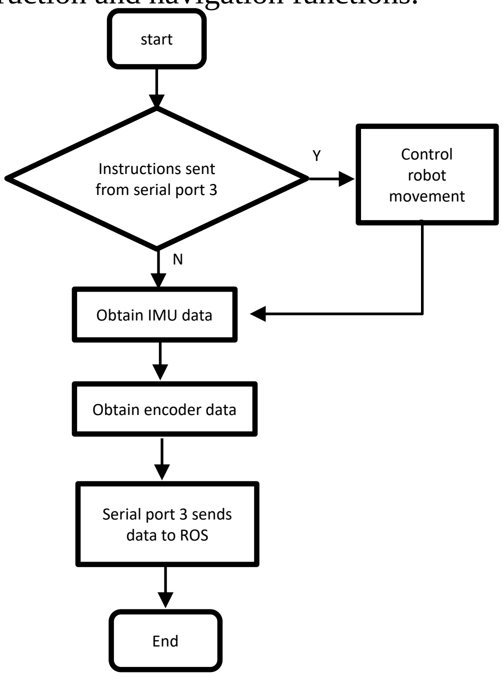


Figure 4: STM32 software code flowchart

## 4.2 Jetson nano end

The main controller of the Jetson Nano uses the ROS software platform to realize functions. ROS is a distributed system. Its rich software library and open source community provide great convenience and support for the development and application of robots [8]. We have a large number of open-source program libraries, function libraries, open-source provided device drivers, related software packages, and other tools. Choosing a distributed system like ROS can meet the requirements of multi sensor, multi actuator, and multi coordinate collaboration for robots, and achieve cross platform embedded device application development. It can conveniently achieve functions such as robot control and communication.

This design uses the Gmapping function package in ROS to achieve positioning and mapping. We have used the navigation stack software package in ROS, which can achieve autonomous navigation and obstacle avoidance functions for robots. Through ROSBridge, communication and data sharing between robots and IoT devices can be achieved [9]. Connecting robots to other intelligent devices can also make robots more intelligent.

## 5. Conclusions and Discussion

The implementation process of this design fully utilizes modern robot technology and artificial intelligence technology, achieving a tour guide robot with functions such as autonomous tour guide, obstacle avoidance, and human-machine interaction. This robot can provide tourists with more convenient, efficient, and personalized tour guide services [10]. It is used for red education bases to develop various red tourism bases using artificial intelligence methods, and to promote the development of the red tourism industry using artificial intelligence technology. Robots implementing the Internet of Things for more intelligent application scenarios have strong promotion and application value.

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