Design of Ackerman Mobile Robot System Based on ROS and Lidar

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Abstract. An ackerman mobile robot system based on ROS and lidar was developed in this research. The i5 industrial control computer was taken as the core controller, and the Ubuntu system was installed inside, the control core of the driving part was the STM32 microcontroller. Using the external environment information obtained by lidar and IMU sensors, the corresponding SLAM algorithm was developed and designed under the Linux system based on the distributed framework of ROS operating system. Through establishing the feature map of environment, the system can locate position and posture of vehicle body in real time, and generate optimal path according to the given target point automatically identify and avoid surrounding obstacles. According to the state of the robot and the commands of the user, it can realize the functions of human-computer interaction, SLAM map scanning and drawing, Wi-fi remote control, real-time positioning, autonomous navigation, etc. efficiently and quickly.

1. Introduction

With the rapid development of computer technology, people have designed and produced a series of robots to meet certain specific needs in different fields around the world. The use of intelligent robot control systems to replace humans to complete some tedious or dangerous tasks has broad application prospects. Robots often use sensors such as lidar (LRF), inertial measurement unit (IMU), and cameras to sense the surrounding environment and drive the robot through wheeled or legged mobile devices.

ROS is an open source software framework mainly based on the Unix platform for operating robots. It not only provides operational support functions such as environmental perception, motion control, and visual operation required by intelligent robots, but also supports the development of functions such as functional verification and virtual simulation of application software system of intelligent robot. At the same time, ROS has gradually become a standard platform for intelligent robot development due to its distributed architecture, multi-language support, and easy expansion. It has achieved good applications in intelligent service robots, unmanned driving, industrial robots and other fields.

This paper proposes and designs a set of low cost and high performance Ackerman structure positioning and navigation control system for wheeled mobile robot based on ROS and lidar, which has the characteristics of high feasibility, wide application range and easy control.
2. Research Methodology
This system is equipped with an inertial measurement unit as an attitude sensor to obtain the overall attitude information and acceleration information of the platform, combined with the wheel speed data as the encoded odometer information, fusion of the odometer and IMU data, and through the extended Kalman filter (EKF) Method, carry out dead reckoning, and realize the estimated calibration of car body attitude and position. In addition, the system is equipped with a lidar sensor to collect the distance information of objects around the vehicle, use the AMCL algorithm for positioning, and calculate the pose of the platform in the world coordinate system [1]. The mobile platform uses the electronic governor as the control drive device; the steering gear is used as the steering device to control the vehicle. When the platform is in motion, based on the obstacle information obtained from the sensor, the optimal path of the platform is obtained through the TEB local path planning algorithm. Combined with the physical characteristics of the platform itself, the upper controller according to the transverse longitudinal control algorithm to calculate the speed and steering control information, the bottom controller receives the target value of the speed and rotation angle transmitted by the upper computer, and controls the steering gear and the motor through the PID algorithm to achieve stable horizontal and vertical control [2].

2.1. Hardware Configuration
At the bottom layer, the 3S battery supplies power to the steering gear and the single-chip microcomputer through the step-down module, and the 2S battery directly supplies power to the ESC. The inductive brushless ESC is connected to the inductive brushless motor. Single-chip output two-channel PWM, respectively control steering gear and motor speed. The top layer is powered by the 3S battery directly to the computer, and the router and lidar are powered by the step-down module. The router is connected to the computer by wire, and the personal computer can be connected to the WIFI generated by the router to realize the control of the mobile platform computer [3]. The lidar and the attitude sensor are connected to the host of the mobile platform to respectively transmit distance information, attitude and acceleration information. These data are fused to obtain comprehensive odometer data. In this way, the computer performs data processing and decision-making on the top layer, and then sends control signals to the bottom layer single-chip microcomputer to control the angle and speed of the platform. The concrete hardware system block diagram is shown as in Fig. 1.

2.2. Software Configuration
In the software system, the lidar driver outputs laser scanning information, the laser odometer rf2o outputs odometer information based on laser data, and the IMU driver outputs attitude and acceleration information, which is fused with the laser odometer through the extended Kalman filter.
program. After that, the final odometer information is obtained and output to multiple functional modules such as mapping, positioning, navigation, and L1 controller. L1 controller module subscribes to odometer data and global path, uses Pure Pursuit algorithm for global path tracking, and uses bicycle kinematics model for motion calculation, uses PI control algorithm to achieve speed closed-loop control, and outputs data to the serial communication module, and then output to the bottom single-chip control module to realize the movement control of the robot [4]. The current solution is that the Gmapping package is used for mapping, the AMCL package is used for positioning, and the move_base package is used for navigation. The program modules are interrelated and cooperate with each other to realize functions such as data collection, data processing, route decision-making, and motion control, and finally achieve the effect of unmanned driving and automatic control.

In move_base navigation, the global path planning uses the dijkstra algorithm, and the local planning uses the TEB algorithm, but the motion parameters planned by the local planner are not executed. In terms of motion, the motion parameters obtained by the combination of Pure Pursuit tracking algorithm and bicycle kinematics model in the L1 controller are executed. However, the local planner is not useless. Because the local path and motion parameters of the local planner are not executed, the local planner will always trigger the global planner to re-plan the path. When the radar scans an obstacle, the global planner can re-plan the path in time to make the global path avoid obstacles, and the L1 controller can then track the global path, so that the motion system can achieve the effect of timely obstacle avoidance [5]. The concrete software system block diagram is shown as in Fig. 2.

![Software system control block diagram](image)

**Figure 2. Software system control block diagram**

### 3. Conclusions
The SLAM robot system built in this article has been tested and can achieve functions such as the establishment of two-dimensional maps, autonomous navigation, and obstacle avoidance. The combination of feedforward control and PID feedback control in the control algorithm of the robot not only improves the real-time performance of speed control, but also shortens the response time of speed. The whole project involves multiple links such as hardware selection, embedded hardware development, ROS project construction and development, embedded software development, and algorithm optimization. It takes a long time to set parameters for each link. After field test in indoor environment, whether it is two-dimensional map establishment, autonomous navigation or obstacle avoidance and other functions, there are very good results. Therefore, it can be used in a certain environment to replace manual labor for certain mechanical operations. On the basis of this project, a depth camera, robotic arm and other peripherals can also be extended to the robot to monitor the situation around the robot in the working environment and gradually achieve the purpose of replacing
labor, and provide more diversified services such as delivery of goods, heavy goods handling, visual navigation, voice recognition, etc.

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