Research and Implementation of Indoor Location for Home Service Robot

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Abstract. At present, the trend of population aging in the world is becoming more and more serious. Many countries have implemented many measures to solve this problem. Various high-tech products to help the elderly and disabled have also entered the lives of the elderly. In order to ensure the safety of the elderly or disabled at home, this paper designs a room using SLAM algorithm of lidar sensor under ROS (Robot Operating System) environment. Wheeled home service robots with internal positioning, mapping and multi-point continuous navigation can collect and analyze environmental data such as temperature, humidity, smoke and rainwater outside the windows and broadcast them by voice while navigation. After many debugging, this design has realized the function of indoor autonomous navigation, and timely alarm and control of abnormal environmental data in the home.

1. Introduction
According to the definition of the International Federation of Robots, service robots are robots that can help people realize semi-autonomous or fully autonomous operation of equipment other than production, processing and manufacturing[1]. Service robots can be classified as home service robots and special service robots [2].

The development of home service robot technology can alleviate the old-age problem caused by the aging population, reduce the pressure of young people’s life, and promote social and economic development[3]. Therefore, the research of home service robots will be of great significance to many aspects of society. At present, most countries in the world are developing robots, of which about 25 countries are involved in the research and development of service-oriented robots. In the field of service robots, Japan, Korea, the United States and Germany are at the forefront of the world. Compared with Japan, the United States and other countries, the research and development of service robots in China started late, but developed rapidly. Home robot localization is a hot issue in the field of mobile robots research, and it is the premise and key of autonomous intelligence for robots to achieve various complex tasks. Sensor positioning is a common method of positioning[4]. Sensors for positioning include ranging sensors (such as sonar and laser sensors) and visual sensors. Vision is the most direct means for human to perceive the noisy environment. Therefore, the development of visual perception ability for robot positioning is conducive to improving its intelligence. Most of the existing localization algorithms rely on sensors carried by mobile robots. In the process of localization, the environment of the robot is unpredictable, such as the environmental changes caused by human
movement and furniture movement. Therefore, it is easy to mismatch and fail to locate only according to the local perception information of the robot body. In order to achieve effective positioning, the robot needs to carry a large number of sensors, which not only increases the load of the robot, but also increases the computational burden of the robot processor. Through the study of the above problems, the SLAM algorithm based on lidar sensor is proposed to realize indoor positioning of service robot.

2. Signal Acquisition of Home Service Robot

2.1. Architecture Design of Home Service Robot

The home service robot is composed of two parts: the moving control system, the environment acquisition and broadcasting system [5]. In the moving control system, the Ubuntu operating system on the raspberry motherboard is used as the software carrier, and the combination of SLAM algorithm in ROS and lidar sensor is used to map and navigate indoors. The structure block diagram is shown in figure 1. The part of environment collection and broadcasting is also divided into two parts: host and slave. Host refers to the part installed in the body of the robot. Random robot moves while slave is fixed in a fixed position at home. The main part includes power supply, motor and motor drive, infrared sensor, ultrasonic, voice broadcasting, camera image transmission, controller and Zigbee wireless communication module. The slave consists of temperature and humidity, smoke and rain sensor module, control module, Zigbee communication module and relay output module.

![Figure 1. Hardware system block diagram of robot traveling.](image)

2.2. Manual Indoor Mapping

Before the home service robot works properly, indoor construction map needs to be done manually. The meaning of the map is to scan the contour map of the room and let the robot have specific reference when it moves on its own. Then it can set coordinates for the robot to navigate by itself and take video and grab objects in real time. Users can also monitor the video at home remotely by mobile App. Home environment data collected by sensors are sent to the host through Zigbee network. The host analyses the data and broadcasts it. When a certain data value exceeds its normal threshold, the host sends the output instructions to the slave and the slave relay acts. The schematic diagram of the environment acquisition and broadcasting part is shown in figure 2.
The basic RPLIDARA1 two-dimensional lidar developed by Shanghai SLAMTEC Company is selected as the lidar sensor. This object is shown in figure 3. Through high-speed rotation, scanning is carried out on a two-dimensional plane with a radius of 360 degrees and a radius of 6m at the center of rotation. Map information of plane point clouds in space is generated by software. This information is often used in map building, robot positioning and navigation applications.

RPLIDARA1 uses laser triangulation ranging technology and SLAMTEC developed high-speed visual acquisition and processing mechanism, which can achieve more than 2000 ranging actions per second [6]. In each ranging process, the lidar transmits modulated infrared laser signal, and the lidar visual acquisition system receives after the laser signal irradiates the target object [7-9]. Through real-time calculation of the DSP processor embedded in the lidar, the distance between the reflected target and the lidar and the current angle information are output from the communication interface. The schematic diagram of its working principle is shown in figure 4.
rotate clockwise under the drive of motor mechanism, and to realize scanning and ranging in 360 degree omni-directional environment.

2.3. SLAM algorithm
SLAM (Simultaneous localization and mapping or simultaneous positioning and mapping) is a concept that the robot wants to determine its position and posture relative to the surrounding objects by continuously scanning and comparing the features of the objects around it. Starting from the unknown position in unknown environment, the feature contours of objects obtained by moving along with themselves are compared and combined to realize location and mapping [10-11]. At present, the two kinds of sensors that achieve better results of SLAM algorithm are lidar and camera. This topic chooses lidar. When the distance between the robot and the object is within the effective range of lidar, the mapping effect is the best. The map contour shows the phenomenon of a straight line without a dotted line. The effect is shown in figure 5.

![Figure 5. Drawing effect map.](image)

3. Software Design of Home Service Robot

3.1. ROS System Framework
The main controller of the robot, remote connection tools and PC (Ubuntu system) are connected to the same WIFI. Node managers and keyboard debugging, SLAM and path planning nodes are established on the PC, and vision, lidar, mileage and basic controller nodes are created on the main controller of the mobile robot. After registering all nodes in the node manager and being managed by the manager, TCP/IP communication can be carried out through the end-to-end topology of the same network to achieve effective communication between nodes on different hosts. Finally, SLAM and path planning can be implemented on PC using the three-dimensional visualization tool RVIZ. The structure of the frame node of ROS system is shown in figure 6.

![Figure 6. ROS System Framework Diagram.](image)
3.2. Programming of Position Control
Before navigating, you need to put the map you built before into the maps folder and modify the map name in the map calling program. After the modification is completed, enter roslaunch pilbot_navigation view_nav.launch in the terminal of the virtual machine to view the map. This command will open the rviz tool. By setting the 2D Nav Goal in rviz, the single navigation of the robot can be realized. The interface is shown in figure 7. The black border is the outline of the built room map, and the red border is the outline of the room that the robot scans in real time.

As ROS node, the position control module firstly analyses the linear velocity and angular velocity transmitted by the basic controller node, and obtains the linear velocity, angular velocity and displacement required by the left and right wheels of the robot. Then, by calculating the actual motion speed, angular velocity and the displacement of the left and right wheels of the robot measured by the encoder, the errors of the motion speed and direction of the robot are obtained. The PID algorithm is used to precisely control the speed of the left and right wheel motors, so that the robot can move according to the path planning trajectory. Finally, the attitude parameters of the robot, such as linear velocity, angular velocity and displacement, are released to the mileage node [12-14]. The flow chart of the program is shown in figure 8.

![Flow chart of position control program.](image)
and rainwater outside the window, and broadcast them by voice. After many debugging, this design has realized the function of indoor autonomous navigation, and timely alarm and control of abnormal environmental data in the home.

4. Conclusion

This paper chooses the SLAM algorithm of lidar as the indoor positioning method. The positioning, mapping and navigation of the robot in the indoor environment are realized. The indoor positioning function of the robot is realized by lidar sensor and motor encoder, and the indoor map is constructed by RVIZ and mapping function package in ROS. Then the initial and target coordinates of the robot are set to realize autonomous navigation through lidar and coder.

In this paper, the robot has four layers. The chassis is made of iron sheets with a diameter of 35 cm and a thickness of 2 mm, so as to ensure that the whole robot can bear enough load. The larger weight objects such as batteries and motors are installed on the bottom to improve the stability of the vehicle. The second layer is equipped with voltage-reducing power supply module, motor drive module and sensor module, the third layer is equipped with control board, communication module and camera module, and the top layer is equipped with a three-axis manipulator. Each layer is connected by four 10 cm long connecting pillars. The robot effect is shown in figure 9. The physical objects produced are shown in figure 10 and figure 11.

![Figure 9. Robot rendering.](image1)

![Figure 10. Robot Level 3 and Top Robot Arm.](image2)
Nowadays, the satellite positioning technology for outdoor positioning is mature, but the convenient positioning method for indoor consumption level has not been truly popular. For example, people use the most frequently mobile phones, mobile phones can easily locate their location accurately outdoors, but when mobile phones enter a more closed indoor, their positioning function almost fails or deviates greatly. This problem is not only the difficulty in the design of this subject, but also the difficulty that science and technology need to break through. Due to the problems of indoor positioning, motion accuracy and product cost, it is still difficult for most of the service robots to really enter the family and integrate into the family. So I hope that in the future, the development of robots and science and technology will promote each other and realize the civilianization of home service robots as soon as possible.

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