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Distributing wheeled mobile robot based on ROS

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Abstract

This paper presents a distributing wheeled mobile robot control system based on Robot Operating System (ROS). The hardware and software are designed according to the function requirement of the mobile robot control system and the characteristics of ROS. The structure of control system, the kinematics modeling and motion control are developed. The communication based on MATLAB-ROS is implemented. The basic motion control of mobile robot is successfully realized in MATLAB. The experimental results indicate that this control system has the advantages of low cost, good expansibility, well flexibility, high-performance and friendly maintenance, and it can control the mobile robot very well.

Keywords: *wheeled mobile robot, ROS, motion control, MATLAB*

1. Introduction

With the continuous development and progress of science and technology, robotic technology has gradually infiltrated into various fields of living and service[1-2]. As a branch of robotics, mobile robot has broad application prospects in services, specific manufacture and other fields[3-5]. The existing mobile robot has many kinds of hardware, the structure of control system is closed, the scalability of systems is poor and the secondary development of systems is difficult[6-9]. Therefore, most of the mobile robot operating systems can not meet the requirements of openness.

ROS is an open-source framework that provides an abstraction level to the complex hardware and software configurations in robotic area[10-12]. It has capability to handle software from low-level up to high-level layers. So everyone all over the world can build and share ROS stack and package for certain purposes[13-15]. ROS is distributed under the terms of the BSD license, which allows the development of both non-commercial and commercial projects[16]. MATLAB has powerful data processing and many mature algorithm functions, which are suitable for algorithm development. Robotics System Toolbox is a new product launched by MathWorks in 2015. Robotics System Toolbox provides common robot algorithms, interfaces and integration between MATLAB and the ROS. We can develop our own robot algorithms in MATLAB.

The structure of control system, kinematics modeling, motion control of the skid steer wheeled mobile robot are researched in this paper. A distributing mobile robot control system based on ROS is successfully developed and the robot prototype is built. The communication between MATLAB and ROS is implemented under the robot control system, and we can control the robot to accomplish simple motion in MATLAB

2. Hardware Design

Skid steer mobile robot has the advantages of simple mechanical structure, flexible movement and strong mobility. The hardware of the skid steer mobile robot consists of power supply, sensors, processor, controller, driver, actuator, etc, shown in Fig.1.

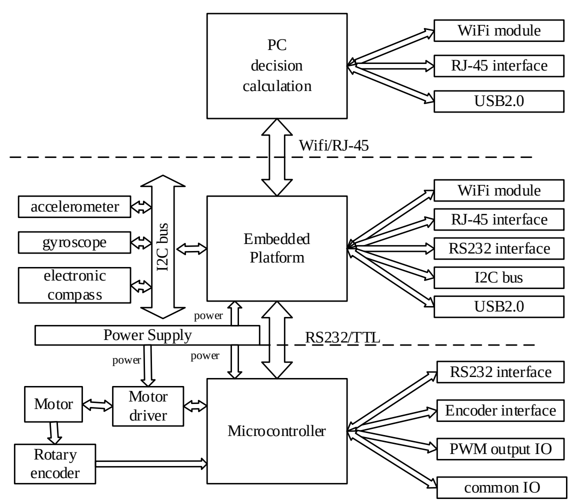

Fig.1. Hardware Layout

The skid steer mobile robot prototype is shown in Fig.2. Four driving wheels are fixed on the frame respectively, the vehicle body is divided into two layers: the bottom layer is equipped with driver, encoder, battery, etc, the upper layer is used for installing controller, sensor, etc.

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Fig.2. The skid steer mobile robot prototype

3. Software Design

According to the hardware structure designed in this paper, the control software of the mobile robot is divided into three parts, shown in Fig.3.

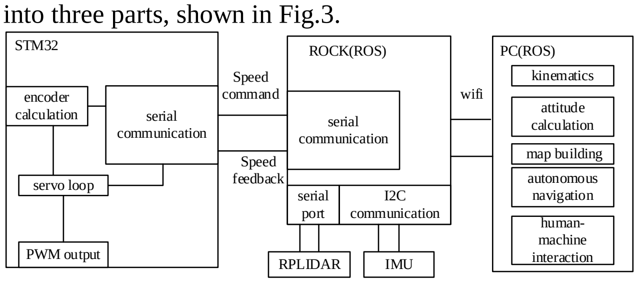


Fig.3. The software system structure

Part 1: STM32. The servo closed loop control of the motor is carried out according to the given instructions of host computer, and the feedback information of the encoder is collected at a certain frequency and sent to host computer.

Part 2: ROCK. The instructions sent to STM32 according to the driving information of PC and obtain the encoder feedback value of STM32 at a certain frequency, then the values are forwarded to PC. ROCK communicates with IMU module through the bus, collects the corresponding information and sends it to PC, reads the data of RPLIDAR through the serial port and sends it to PC.

Part 3: PC. Including the basic modules such as robot kinematics control, inverse kinematics, attitude calculation and other complex algorithm module.

ROS nodes run on the ROCK and the PC respectively, Fig.4 is the node distribution graph.

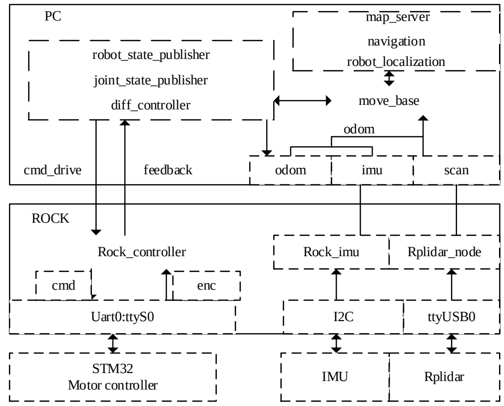


Fig.4. The node distribution

4. Kinematic Analysis and basic control

To realize the control of mobile robot, we must establish its kinematics model. Suppose $\omega_1 = \omega_3 = \omega_L$, $\omega_2 = \omega_4 = \omega_R$, The kinematic model of the mobile robot is shown in Fig. 5.

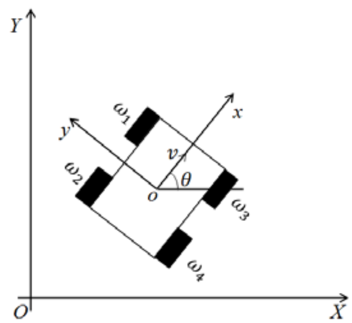


Fig. 5. The kinematic model

As illustrated in Figure 5, the kinematics equations of the mobile robot are as follows：

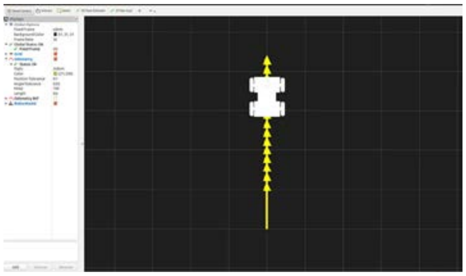
$$\begin{bmatrix} \dot{X} \\ \dot{Y} \\ \dot{\theta} \end{bmatrix} = \begin{bmatrix} \cos\theta & 0 \\ \sin\theta & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} v \\ \omega \end{bmatrix}$$

$$v = \frac{\omega_L r + \omega_R r}{2}$$

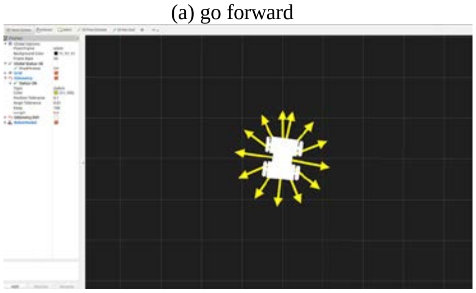
$$\omega = \frac{\omega_L r - \omega_R r}{b}$$

v is the linear speed of the mobile robot, ω is the angular speed of the mobile robot，b is the wheelbase of the mobile, r is the radius of the mobile robot.

Now, we can control the basic motion of mobile robots, for example go forward, go backward, turn right, turn left, etc. The trajectory of the mobile robot in RVIZ and the speed curve of left and right wheel are shown in Fig. 6 and Fig. 7 respectively.

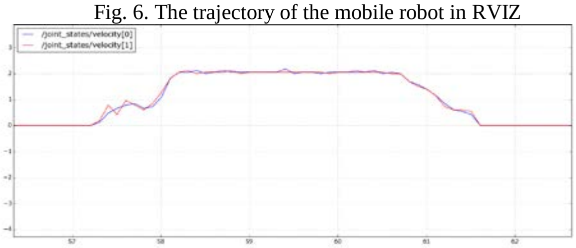


(a) go forward

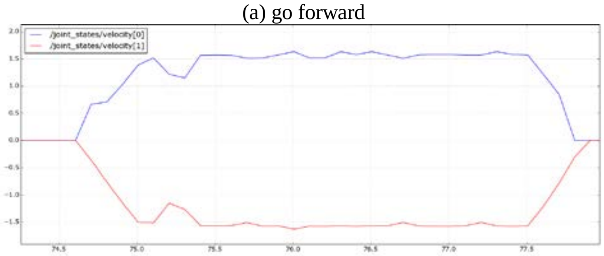


(b) turn right

Fig. 6. The trajectory of the mobile robot in RVIZ



(a) go forward



(b) turn right

Fig. 7. The speed curve of left and right wheel

In Fig.7, /joint_states/velocity[0] (blue line) stands for the speed of the left wheel, /joint_states/velocity[1] (red line) stands for the speed of the right wheel.

5. Controlling mobile robots in MATLAB

MATLAB has powerful data processing and many mature algorithm functions, which is very suitable for algorithm development. Developing algorithms of robots in MATLAB is important. The mobile robot is controlled at speed of 1m/s. The specific steps of the communication based on MATLAB and ROS are as follows:

Step 1: System configuration

The host machine runs Ubuntu and ROS. Suppose the IP address is 192.168.0.103; The slave machine runs MATLAB 2015 or above versions under the windows platform. Suppose the IP address is 192.168.0.103; The host machine and the slave machine are placed on the same network segment through the wireless network. Windows need to close the firewall.

Step 2: Setting ROS environment variables

On the slave machine, enter the following command in the MATLAB command window to set the environment variables:

setenv('ROS_MASTER_URI','http://192.168.0.104:11311');

setenv('ROS_HOSTNAME','192.168.0.105');

Step 3: Start Master node

First, start roscore at the Ubuntu terminal, then start the rosinit at the MATLAB command window and create a new global node.

The IP addresses of three platforms are shown in Fig.8:

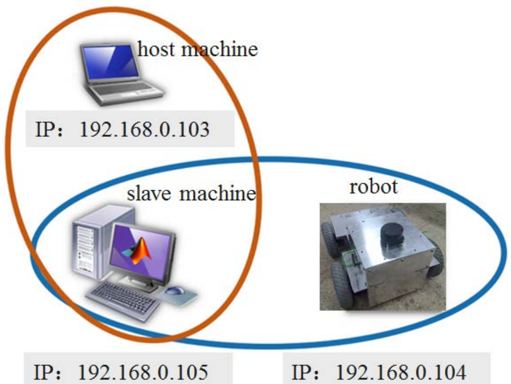


Fig.8. IP addresses of three platforms

In order to control the speed of the mobile robot, we need to publish the /cmd_vel topic and send speed messages to the topic. In the MATLAB command window, enter the following instructions:

```
>> cmdpub = rospublisher(' /cmd_vel',
        rostype.geometry_msgs_Twist);
>> cmdmsg = rosmessage(cmdpub);
>> cmdmsg.Linear.X = 0.2;
>> cmdmsg.Angular.Z = 0;
>> send(cmdpub,cmdmsg)
```

In the MATLAB command window, enter the following instructions：

```
rostopic echo /cmd_vel
```

If the content appears in the workspace window as shown in Fig.9, it indicates that the linear speed of the mobile robot is 0.2m/s.

```
>> rostopic echo /cmd_vel

  Linear
    X :   0.2
    Y :   0
    Z :   0
  Angular
    X :   0
    Y :   0
    Z :   0
---
```

Fig.9. The linear speed of the mobile robot

6. Conclusions

This paper proposes a mobile robot control system based on ROS with the hardware and software structure. The paper also shows a skid steer mobile robot prototype of the system. The mobile robot can realize map building and autonomous localization. For the controlling of the mobile robot, this paper studies the Robotics System Toolbox in MATLAB. The communication between MATLAB and ROS is implemented under the robot control system, and the robot can be controlled to achieve simple movement in MATLAB. The research of this paper lays the foundation for developing mobile robot algorithms in MATLAB.

Acknowledgments

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References

[1] Wang hong peng, Yang yun, Liu jing tai. Research status and development trend of mobile robot[J]. Automation and instrumentation,2011,12:1-4.
[2] Wang guo biao, Chen dian sheng, Chen ke wei. Research status and development trend of biomimetic robot[J]. Journal of Mechanical Engineering, 2015,13:27-44.
[3] Kumar, K,Reel, PS. Analysisof Contemporary Robotics Simulators. Proceedings of ICETECT, 2011:661–665.
[4] Tianran Peng, Jun Qian. Mechanical design and control system of an Omni-directional mobile robot for material conveying. Procedia CIRP, 2016,56:412–415.
[5] Pavel,S, Pavel,V. Control system of a Semi-Autonomous mobile robot. IFAC Papersonline, 2016:521–525.
[6] Ivan T, Zarko M, Danijela D,etc. Thermal vision based intelligent system for human detection and tracking in mobile robot control system[J]. Thermal Science, 2016,20(5):1553-1559.
[7]Nat Tuck, Michael Mcguinness, Fred Martin. Optimizing a mobile robot control system using GPU Acceleration[J]. Journal of Mechanical Engineering, 2015,10:28-37.
[8] Fabrice R, Noreila. Integrating multirobot coordination in a mobile robot control system. IEEE International Workshop on Intrlligent robots and systems, 1990,20(1):43-49.
[9] Iocchi L, Nardi D, Piaggio M,etc. Distributed coordination in heterofeneous multi-robots systems[J]. Autonomous Robots, 2003,15(2):155-168.
[10] Balakirski,S, Kootbally, Z. USARSim/ROS A combined framework for robotic control and simulation. Proceedings of the ASME 2012 International Symposium on Flexible,2012:1-8.
[11] MSc, Andres Belzunce, Ming Li. Control system design of a teleoperated omnidirectional mobile robot using ROS. IEEE 11th Conference on Industrial Electronics and Applications, 2016:1283-1287.
[12] Zhen An, Lina Hao, Yu Liu, Li Dai. Development of Mobile Robot SLAM Based on ROS[J]. International Journal of Mechanical Engineering and Robotics Research, 2016,5(1):47-51.
[13] Tatiana Pinho1, António Paulo Moreira2, José Boaventura-Cunha. Framework Using ROS and Sim Two Simulator for Realistic Test of Mobile Robot Controllers. Proc. of the 11th Port. Conference on Automous Control, 2014:752-759.
[14] Said Benaissa, Fouad Moutaouakil, Saadia Tallal. Modelization and implementation of EKF localization for mobile robot using ROS. 13th International Conference on Informatics in Control, Aotomation and Robotics. 2016:1-7.
[15] E Ruiz, R Acuna, N Certad, etc. Development of a control platform for the mobile robot Roomba using ROS and a Kinect sensor[J]. Robotics Symposium&Competition, 2014,10:55-60.
[16] M. Quigley, K. Conley, B. Gerkey, J. FAust, T. Foote,J. Leibs, E. Berger, R. Wheeler, A. Ng. ROS: an open-source Robot Operating System. International Conference on Robotics and Automation. 2009:3-5.

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