Development of An Intelligent Interaction Service Robot Using ROS

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***Abstract*— The research and development of intelligent interaction service robot become popular these years. Human-robot interaction play an important role in service robot as the intelligent behavior is natural way that people communicate with robot. This paper presents Xinxin, an intelligent interaction service robot designed as receptionist, partner and a mascot of 120th anniversary of XJTU. The robot combines simultaneous localization and mapping (SLAM), somatosensory interaction with the robotic arm, voice command, remote control by workstation and telephone's APP, using Robot Operate System (ROS) as the core of information processing. This paper describes the software and hardware platform of the robot, and the solution of system integration. Finally, experiments shows that the robot has reliable and effective performance on human-robot interaction.**

Keywords—Service Robot; Human-robot Interaction;ROS; SLAM; Kinect

I. Introduction

With the rapid development of robotic technology, Service robot has gradually entered into homes, offices and other places to help the old or the disabled for improving the quality of people's daily life [l]. According with the *International Federation of Robotics* in *World Robotics 2014 Service Robots* report that the global service robot market sales of about $5.97 billion in 2014 [2]. Nowadays, service robot market scale is growing rapidly in the world. A receptionist robot is a special kind of service robots that is designed for personal use at office environments [3]. People need the intelligent, safe and effective service from the service robots.

Human-robot interaction play an important role in service robots as it is a natural way that people communicate with robot. There are many methods of human-robot interaction that already proposed, such as somatosensory interaction, voice interaction, and face recognition and so on. Localizing itself and navigating to destination within the working environment is the most important ability for truly intelligent service robot. Gesture recognition has a wide application including Human Machine Interaction (HMI), Human Robot Interaction (HRI) and Social Assistive Robotics (SAR) [4]. It has been pay close attention that through speech recognition communicating with a lot of devices.

As a receptionist and partner, the robot need to be able to autonomous navigation, voice command, gesture recognition and follow the guest, etc. From a cognitive level the interaction robot can detect human and aware when a person wants to interact with the robot [5].

In this paper, we design an intelligent interaction service robot using Robot Operating System (ROS). It perform well at its tasks about guiding and interaction of voice and gesture. As the characteristic that ROS is open source, the robot is not only a product but also a platform that can add more sensors to increase the intelligence of the robot. The paper also present a low-cost solution to make a service robot that can receive the tasks as the Kinect and Rplidar A1 are highly cost-effective sensors and the shell was manufactured by 3D-Print.

The rest of the paper is organized as follows. Section II presents the components of the robot. Section III describe the feature of the robot and experiments results. Finally, Section IV presents some conclusions and further improvement measures.

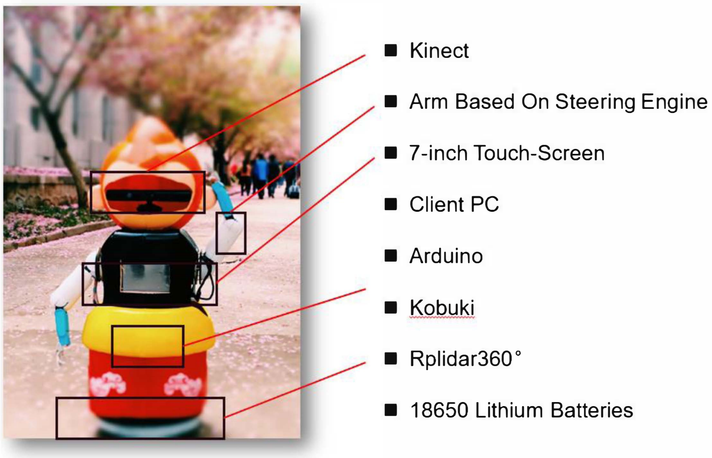

Fig. 1. The Structure of the Service Robot.

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II. Components Of The Solution

A. Robot Operating System (ROS)

In this system, the Robot Operating System (ROS) is used to control the hardware platform which was installed in Ubuntu 14.04 on the Client PC and Workstation PC. ROS provides libraries and tools to help software developers create robot applications. It provides hardware abstraction, device drivers, libraries, visualizers, message-passing, package management, and more. ROS is licensed under an open source [6]. It requires a Linux distribution base operating system to operate, this provides the layer between ROS and the actual laptop hardware, ROS includes hardware abstractions and low level device controls in order to control the connected devices whether they are robots or sensors connected to the actual laptop itself [7].

We can design each function as a node and make these node running simultaneously, taking the place of designing a whole and unique system for all the functions [8]. FIG. 2 shows the process of communication between nodes. .

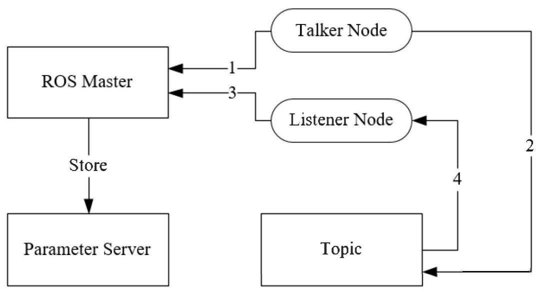

Fig. 2. The Process of Communication between Nodes is 1-2-3-4[8].

B. Hardware Platform

The hardware platform of the robot was designed not only a specially service robot but a platform for service robot as the modular design. The hardware platform consists of six modules, mobile module, laser scanning module, somatosensory module, arm module, display module and voice module.

Considering the demand for low cost of service robot, we select some highly cost-effective sensors and Controller such as Rplidar A1, Kinect and Arduino which are adapted the ROS.

The Kobuki, shown in Fig.4 has highly reliable odometry and long battery hours and provides power for an external sensor and actuator. It provides access to open source software, including ROS that make it easy to research and develop the applications. We also customized the battery used 12-cell 18650 Lithium batteries to achieve long battery life and about 6 hours working time of the robot.

As the laser scanning module, the Rplidar A1, shown in Fig.3 is used to achieve the function of location and navigation. RPLIDAR A1 is a low cost 360 degree 2D laser scanner (LIDAR) solution developed by SLAMTEC. The system can perform 360degree scan within 6meter range. Its scanning frequency reached 5.5 Hz when sampling 360 points each round. And it can be configured up to 10 Hz maximum. Nowadays, the Rplidar has been supported the ROS and the Arduino that make the ROS developer can easily use it.

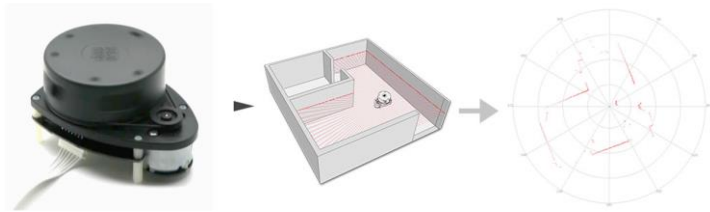

Fig. 3. The Rplidar 360° Laser Range Scanner.

As the somatosensory module, the Microsoft Kinect, shown in Fig.4 is selected to get the gesture of human for controlling the robot arm. It consists of several sensors including a RGB sensor, a 3D depth sensor, multi-array microphones and an accelerometer. Using the ROS OpenNI that is open source project focused on the integration with ROS [9], 16 skeletons can detected , and be showed with different colors and numbers on the screen. Each skeleton contains 15 fixed frames including: head, neck, torso, shoulder, elbow, hand, etc. [10]

The Arduino Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started

In this paper, the mini Industrial Personal Computer is used that operate the Ubuntu 14.04 and it has i5-4200UCPU, 8G RAM and 128G SSD that make the system running smoothly.

III. System Integration And Discussion

Our system mainly consists of three parts: the sensors, the ROS framework in Client PC and Workstation PC, and the actuator. The first part give the data of the robot state and other environment information to ROS framework. The second part is the communicate center of whole system. It process the data and make the decision to the actuator. The last part perform the action and display the information of the system.

A. Simultaneous Localization And Mapping (SLAM)

We experimented the GMapping and navigation in the foyer of the office building. The physical measurement is shown in Fig.7

Fig.7. shows the generated map for scanning the office environment using the GMapping SLAM algorithm running on the robot. The areas where have burr area bonsais and some clutter. Intuitively, the generated map shown in Fig.7 and the physical measurement map is roughly the same on the contour. When we experimented, there are also some people around but they have not been added to the map.

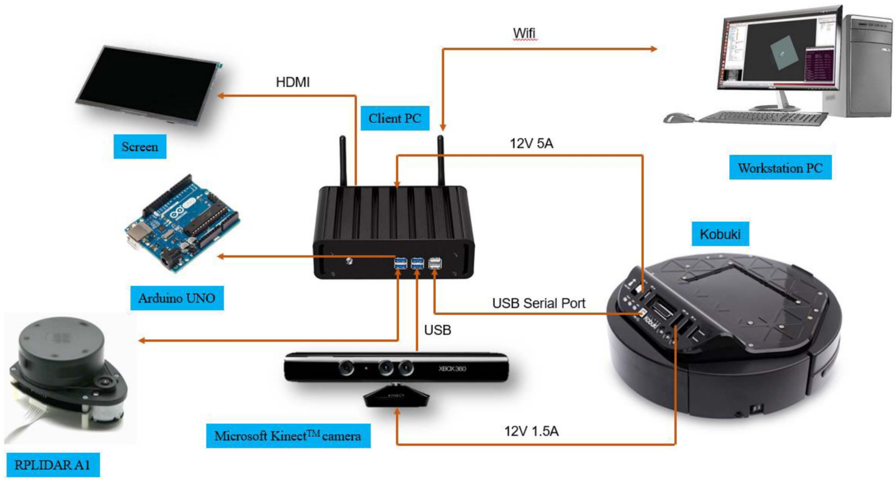

Fig. 4. The Hardware Platform.

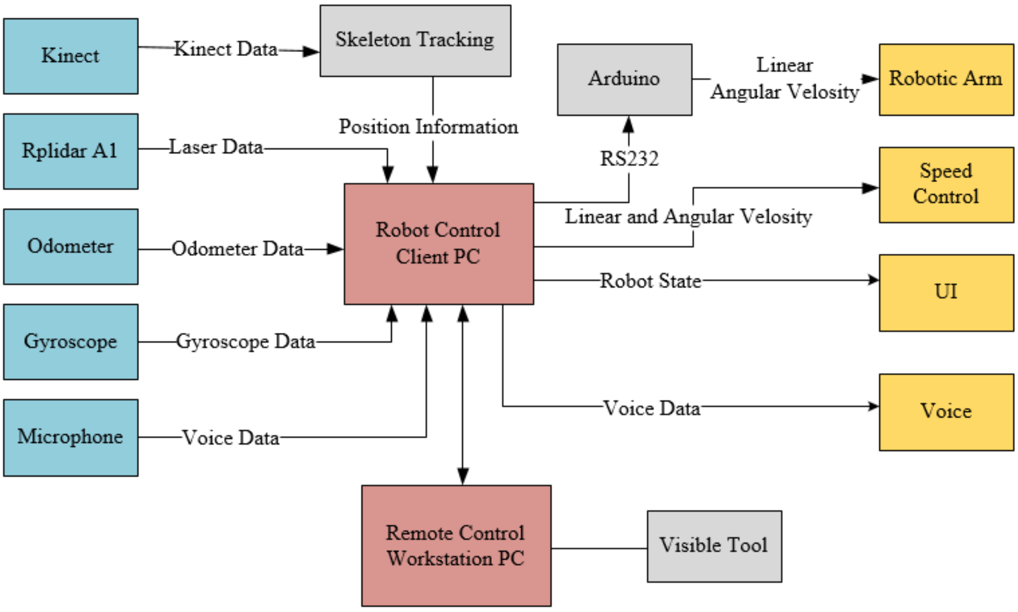

Fig. 5. System overview.

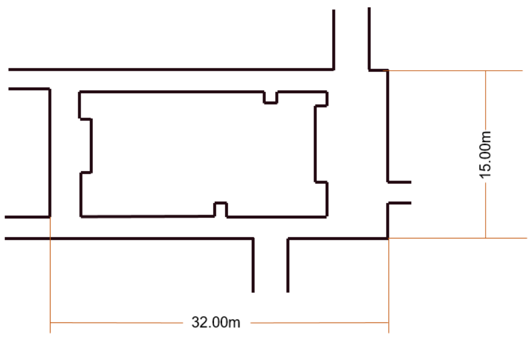

Fig. 6. Physical measurement of the foyer.

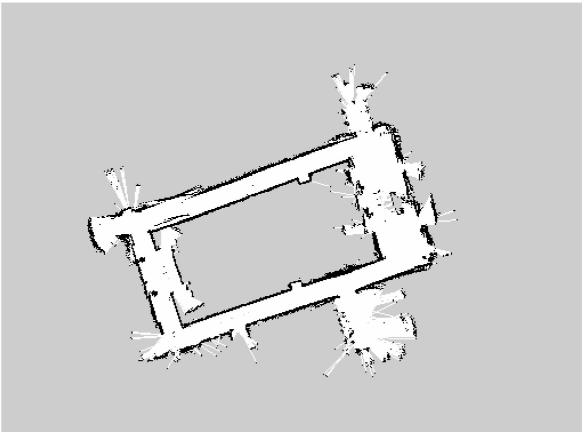

Fig. 7. Generated map for scanning the office environment.

B. Somatosensory interaction

As the somatosensory interaction, several pose are defined to make the robot arm achieve different actions. Fig.7 show the performance of skeleton detection. Each joint has 3D position (x, y, z), X is the horizontal axis, Y is the vertical axis and Z is the distance between the joint and the Kinect sensor [12]. We collect the value of the each joint and make comparisons to send commands to the Arduino that controls the arm.

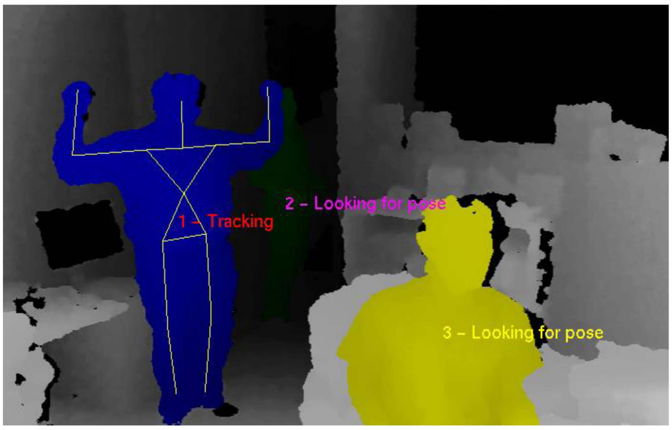

Fig. 8. Skeleton detection using openni_tracker.

C. Voice Interaction

We developed the voice recognition system for the robot based on iFlyTek Speech Lab System that provide the service of speech synthesis, speech recognition, voice dictation, and semantic comprehension. For sending commands to the robot, we convert the voice into ROS messages, and develop the node to subscribe the messages. As the advantage of iFlyTek Speech Lab System, the voice not only command the mobile of the robot, but also is gave the feedback to the sounder like doing a simple dialogue. We implement the experiments about the online and offline speech recognition system and the result is shown in Table 1.

TABLE I. ACCURACY OF THE SPEECH RECONGNITION

	Environment	Accuracy
Online	Non-Noisy	93%
	Noisy	76%
Offline	Non-Noisy	88%
	Noisy	71%

D. Internet Plus

As ROS is a distributed computing environment and its network configuration is complete, bi-directional connectivity between all pairs of machines, on all ports [13], it make it possible to build the connection of different machines. The APP that developed based on rosjava can connect the robot easily and workstation PC also can connect the robot to get the state and remote control, shown in Fig.9.

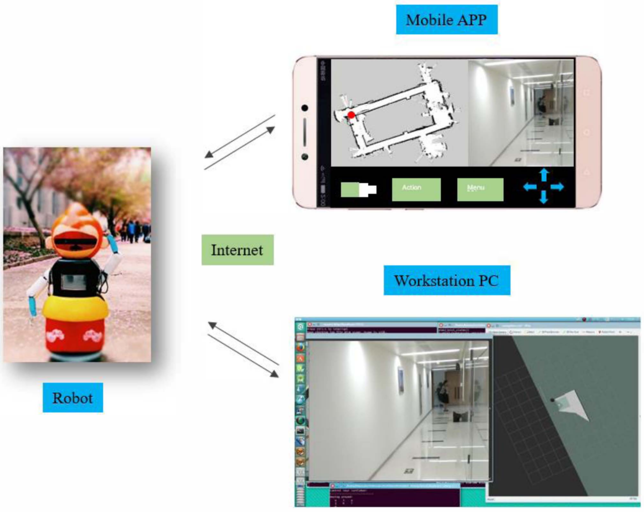

Fig. 9. Internet connection between different machines.

IV. CONCLUSIONS AND FUTURE WORK

With strong social and economic motivations, intelligent interaction service robot is an important goal of development. In this paper, firstly we described the components of the system include the software and hardware platform. And then we discussed the system integration, including simultaneous localization and mapping, somatosensory interaction, voice interaction and internet plus, and some experiments. Through the paper, it prove that the robot is reliable and powerful using ROS. The ROS is the core of the information processing of the robot, and make it easy build a system not starting from scratch.

There are also are improvements that can enhance the intelligence and experience of the service robot. The first area of the future work is to enhance the integration level of the system. On the basis of the hardware platform, there are still some function can be developed. For example, the gesture recognition, voice recognition and mobile function are implemented deep integration. Improving accuracy of location and navigation of the robot is the next future work and continuous work. This is important as they are the foundation of the mobile robot that it can realize what the environment around itself and where to go. Lastly the community of service robots is the future development trend. It will be the highlights of the research that the service robots link in map. With the developments on the basis of the current work, this system will be more intelligent and more interaction features.

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