RoboCup Rescue 2016 Team Description Paper Team Nubot

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Info

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RoboCup Rescue 2016 TDP collection: https://to-be-announced.org

***Abstract*—To participate the RoboCup Rescue Robot competition, our team designs the Nubot rescue robot from mechanical structure to the electronic architecture and software system. Mechanical structure has good movability. The robot is quite smart so that it is hard to trap the robot even facing the complex terrain. The electronic architecture is built on industrial standards which can bear electromagnetic interference and physical impact from the intensive matches. The software system is developed upon the open source Robot Operating System, which provides similar operating system services including hardware layer abstraction, the underlying of device control, the achievement of common functions, the delivery processes of messages and the package management.**

***Index Terms*—RoboCup Rescue, Team Description Paper, Structure.**

I. Introduction

At present, there are many research institutions doing researches in this field, dif-ferent kinds of outdoor mobile robot including wheeled, legged, tracks and so on. Of which track has stronger motion ability and higher adaptability to the outdoor natural environment, and has been widely used in various type design of rescue exploration robot. But the traditional double-tracked construction in the face of obstacles with large size environments, it is apparently lack of better climbing ability. It is prone to stuck, overturning and so on when in more dramatic change terrain.

In this paper, with the specific requirements of rescue robot platform in the com-plex environments, it is designed of a three-section six-tracks robot platform, based on the original power track, focus on improving the climbing ability of front and rear fins, to make the robot platform more adaptive in the face of more dangerous terrain with oversize obstacles. Figure 1 shows the platform.

This system coordinate with laser range finder, inertial measurement unit, micro-phone, head camera and other ex-tensions accessories. Send back through the real-time image information through camera to achieve remote control, it can achieve a stable moving in complex traffic environment. According to the site needs to create the local environment map, and complete real-time interactive of video and audio information and other tasks. At the same time as the increasing numbers of robot task types and functional re-quirements, higher requirements for real-time and stability of the electrical system platform has been put forward. In order to facilitate the robot platform with continued expansion sensors, actuators, and to ensure real-time communication during the controlling process, the robot platform was introduced PC-based control technology and EtherCAT fieldbus based technology in the electrical level. The platform can also ensure the system real-time and stability in a highly complex environment.

Fig. 1. Photo of Nubot Platform.

II. System Description

A. Hardware

Sensors for Navigation and Localization For better known of the terrain around the robot, laser range finder (LRF) is more accurate and rapid than PTZ camera. It can detect the obstacles and generate a local map, and then feedback it to the robot. UTM-30 lx (shown in figure 2) designed by HOKUYO company is used in the Nubot robot platform. With 30 meters detection range, 270 measuring range, DC12V input, 25 ms scan time, it can work under the 100000 lx light intensity, effectively adapting to the demand of outdoor environment.

While performing tasks in outdoor environment especially crossing the obstacles or steep slope, the robot needs detecting its own posture. The robot cannot adopt large electronic compass, because the power supply of the robot is limited by the battery capacity. Inertial measurement unit (IMU) is a common choice to solve this problem. The production (shown in figure 3) of Xsens Technologies is chosen as the master of translation and interpreting. With low power consumption and direction drift, it provides calibrated three-dimensional acceleration, angular velocity and magnetic field strength.

Combined with IMU and LRF, the robot can get the accurate map about the terrain around it. According to the requirement

Fig. 2. HOKUYO laser range finder UTM-30 lx.

Fig. 3. Xsens inertial measurement unit.

of the competition rules, the victims have such signs of life: visual, thermal, motion, sound and CO2. Our team uses camera, carbon dioxide sensor, infrared sensor and microphone to identify the victim.

Robot Locomotion

The mechanical structure of Nubot is shown in figure 4. Every three tracks are set at each sides of the robot body as a group. Each group of three tracks consists of front-fin, main-track and back-fin. The couplings of the tracks could rotate freely by the motor drive.

Crossing normal terrains, the robot platform raises the front-tracks and back- tracks to shrink the contact surface between the tracks and the ground, which greatly reduces the frictional resistance and enables the robot platform to veer quickly with less radius of turning circle. In the process of traveling though the complex terrains, the couplings could be driven to rotate for changing the relative posture of the tracks, which increase the contact surface to provide the robot platform enough mobile power.

For example, when dealing with the subsidence road, the robot puts the front-tracks and back-tracks horizontally to extend the length of the robot and the contact surface, which provides extra grip and power to enhance the adaptability of complex terrains. And by changing the relative position of the tracks, the robot could actively adjust the center of gravity while climbing oversize obstacles or stairs.

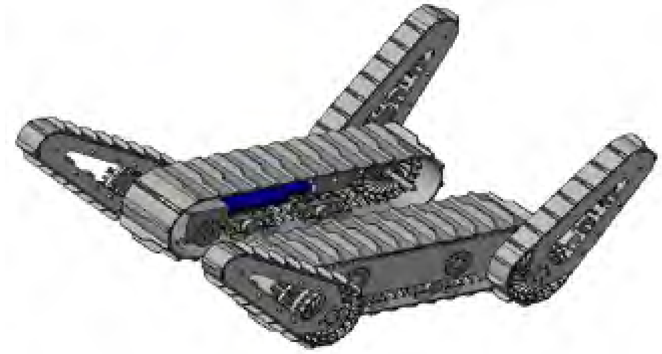

Fig. 4. Standard robot platform: Nubot Rescue Robot.

Fig. 5. The tracks appearance and sliding cross coupling.

For tracks, larger contact surface will provide more grip and power for the robot platform to travel, which on the contrary means more frictional resistance and energy dissipation in turning. The tracks appearance of Nubot robot platform is shown in Fig 5, which is designed by both considering the motive power and turning flexibility to ensure that the robot have enough power to cross the obstacles and keep the turning center is exactly the body center of the robot.

The power source of the robot platform provided by four drive motors. Considering that the tasks are mainly performed in outdoor environments which require sufficient drive power and loading. The drive motor of Maxon-241412 has the power of 150w and the reduction ratio of 26:1, which provide enough power to dealing with most of the complex terrains. Two drive motors placed at the both sides of the robot are the main power motors (motor1 and motor2 in Fig 6, which drive the two main tracks forward or backward. And though the differential

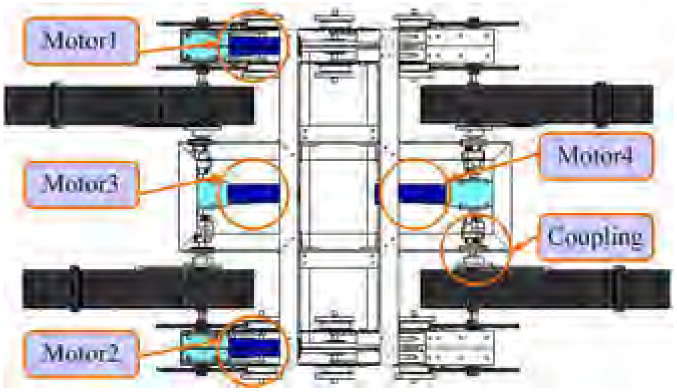

Fig. 6. The drive motors configurationg.

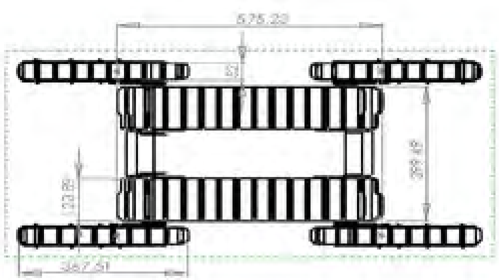

Fig. 7. The mechanical structure of the robot platform.

motion of the two drive motors, the robot could turning on the spot. The other two motors (motor3 and motor4 in Fig 6 control the two groups of fins to rotate up or down by driving the couplings, which help the robot to climb the obstacles or to cross the subsidence area. For compensating for the relative error of the couplings, the sliding cross coupling is configured at the four joints.

The mechanical structure of the robot platform is as shown in the Fig 7. The size of the robot platform is decided by the motive power, load weight, task characteristics of the platform and some other factors. Larger size offers the robot better stability and load weight, but often increase the burden of power system and reduce the endurance time. The technical parameters of the Nubot robot platform are listed in the Tab.1, which are designed to balance the strong power, flexibility and endurance time for adapting the complex terrains.

B. Software

Refer to Table I in the Appendix.

After we set power to the robot, we can drive the robot in 2 modes. One is artificial control, and the other is autonomy. In artificial control, the robot uploads the camera driver, and the operator drive the robot with the real-time video information. In autonomy mode, through the SLAM arithmetic, the robot searches the unknown area all by itself. If there is any problem just like mechanical broken, system break-down, electrical issue or box damaging, we can stop the robot by GUI control button. The GUI window is shown in figure 8.

Map generation/printing

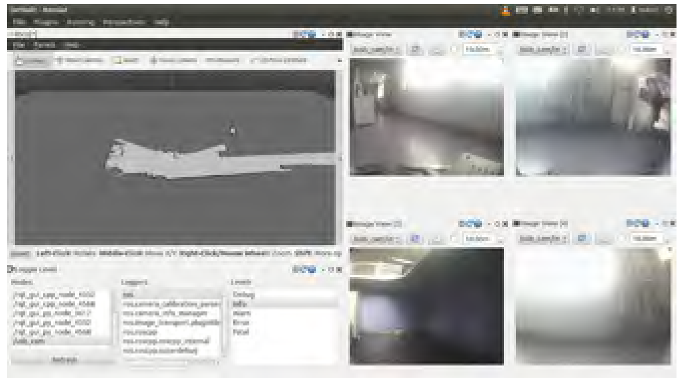

Fig. 8. Nubot GUI.

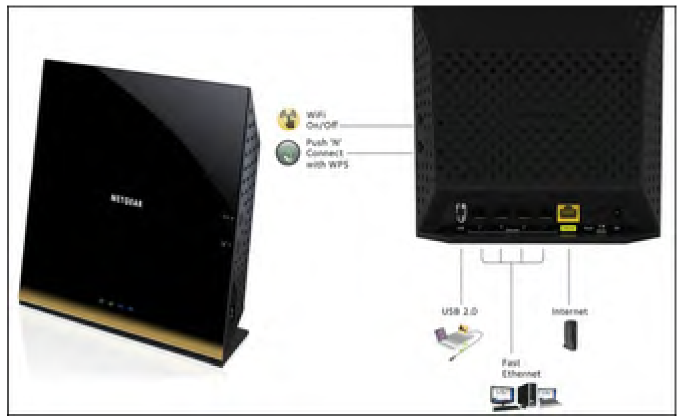

Fig. 9. Netgear router R6300 v2.

The purpose of the mission is the robot gets the map of the whole environment, no matter the robot is autonomy or artificial control. Our strategy is the moment we put the robot in line, the robot uploads the laser drivers and begins mapping. If the robot drops out during searching, we save the present map and restart the SLAM system. After the robot accomplishes the mission, we submit the best one of the maps. Our SLAM system bases on the architecture of the German team Hector Darmstadt.

C. Communication

During the competition, we used two NETGEAR double-frequency gigabit ac 802.11wireless routers (shown in figure 9) to form a wireless network. As the requirement of the competition, the router works in 5 GHz channel network. The communication rate of up to 1750 MBPS makes that the mobile robot under complex electromagnetic environment can also achieve the basic communication function. In the case of chaotic wireless channels, it is still able to stay at least 640 MBPS transmission rate. And it provides the basis of bandwidth for transmission video, voice and data security for remote control. In addition, the robot will also configured mechanical arm with many degrees of freedom, microphones and other sensors.

III. Application

A. Set-up and Break-Down

Before participating the league, our team makes sure of the status of the robot at first. For reducing the time at the most content, our team divides the operator system into two parts. The first part is the essential system which ensures the basic robot locomotion. When we set power to the robot, it upload the basic locomotion driver automatically by the scripts. Then the operator can drive the robot by joystick, and the laser range finder begins mapping. The second part is GUI control. After we set power to the robot, we can control the robot all by our GUI. So after the operator get ready at the operator station, we move the robot in line and set power to the robot. Within 1 min, the robot uploads the essential system and is driven by the operator.

B. Mission Strategy

We give up the manipulator mission and would only participate in the autonomous mission.

C. Application in the Field

In a real disaster environment, the movability and the communication robust always are the issues perplexing the rescue team.

To improve the movability of the robot, we assemble four fins to the platform. And each fin has a passive track which can gains the frictional grip. While crossing the oversize obstacles, the Nubot can change geometry configuration for climbing and landing safely.

The next issue is communication including external communication and interior communication. External communication is the telecommunication between robot and operator. To solve the problem, through bridging two NETGEAR 6300v2 double-frequency gigabit ac 802.11 wireless routers are used to form a wireless network, which can work in 5 GHz channel network. Interior communication is the electrical communication between actuators, sensors and control computer. Our team choose Beckhoff C6920-0040 as the IPC, (shown in figure 11-1) which is proved performing well in resisting electromagnetic interference and physical impact from the environment.

IV. Conclusion

We will learn a lot in this competition to improve our robots.

Appendix A
Team members and Their Contributions

Please use this section to recognize all team members and their technical contributions. Also note your advisors and sponsors, if you choose. You may want to include links to homepages.

- Yi Liu — Mechanical design
- Yuhua Zhong — SLAM algorithm
- Xieyuanli Chen — Robot-human interface
- Pan Wang — Software design

TABLE I
Software List

Name	Version	License	Usage
Ubuntu	14.04	open	
ROS	indigo	BSD	
PCL [1]	1.7	BSD	ICP
Hector SLAM [2]	0.3.4	BSD	2D SLAM

Appendix B
CAD Drawings

The mechanical structure of the robot platform is shown in Fig 7.

Appendix C
Lists

A. Systems List

We are still changing our robots' structures to fit in the rules. We will update the TDP after the competitions.

References

[1] R. B. Rusu and S. Cousins, "3D is here: Point Cloud Library (PCL)," in *IEEE International Conference on Robotics and Automation (ICRA)*, Shanghai, China, May 9-13 2011.

[2] S. Kohlbrecher, J. Meyer, O. von Stryk, and U. Klingauf, "A flexible and scalable slam system with full 3d motion estimation," in *Proc. IEEE International Symposium on Safety, Security and Rescue Robotics (SSRR)*. IEEE, November 2011.