NuBot-RESCUER Team Description Paper 2010

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Abstract. The paper mainly presents the approach of our rescue league robot team "NuBot-RESCUER" for RoboCup 2010. We introduce our latest locomotion system which is designed to be maneuverable on uneven terrains, discuss the mechanical structure, the composition of control hardware, control method and efficient human-robot interface in the system. The method of map generation and the mapping process are also described.

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Comment [w2]: methods
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1 Introduction

RoboCup is an international research and education initiative. Its goal is to foster artificial intelligence and robotics research by providing a standard problem where a wide range of technologies can be examined and integrated [5]. The rescue league competition of RoboCup involves in search and rescue applications, provides objective evaluation of robotic implementations in representative environments [6].

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NuBot-RESCUER is a team composed by students and originates from the former NuBot team which has taken part in RoboCupSoccer middle size league since 2003. We started working in the domain of rescue robot field from 2006. Up to now, we have designed two versions of the NuBot-RESCUER robots and participated in several robotic competitions in rescue, which led up to considerable results, and continuously won the championship of RoboCup China Open in 2007, 2008 and 2009. Our main focus concerns on design of Rescue Robot, SLAM based on Laser Range Finder, with an emphasis on advanced mobility and automatically mapping .We are going to present our recent approaches in RoboCup 2010.

2 Team Members and Their Contributions

The core team this year consists of:

Hui Zhang	Team Leader
Dan Hai	Hardware and mechanical design
Wentao Yu	Computer vision

Xiangdong Cai	Software infrastructure and SLAM
Dengke Zhu	Hardware
Shaoke Qian	Electrics design and control
Xun Li	Advisor
Zhiqiang Zheng	Advisor

3 Robot Locomotion

The robot (Fig.1)named β -II is improved from its first version. It is a 6-tracked vehicle, which is maneuverable on uneven terrains. The architecture of chassis can be divided into three parts: front, middle and rear part. Each part contains two tracks. The drive system consists of two of 24V DC, 150W motor for driving two main tracks in the middle part, which moves the robot ahead, backward, left or right. Another two pairs of tracks are respectively driven by two DC motors, which can rotate 360 degree. When facing stack environment, the robot can overcome the stack by using its front and rear tracks up and down like 'climbing'. The 6-tracked construction is useful, especially crossing stairs, ramps and stepfield pallets.

The tracks are made of rubber and designed specially for our robot by ourselves, which is suitable to many different environments.

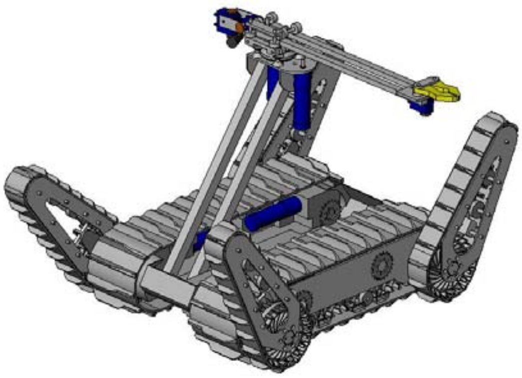

Fig. 1 The construction of our current rescue robotβ -II

Before robot β-II , we have developed an initial version named robot β, which is simpler than robot β-II . It has only one pair of tracks in the front of robot, whereas it weights lighter, which leads to more powerful locomotion, as Fig.2 shows.

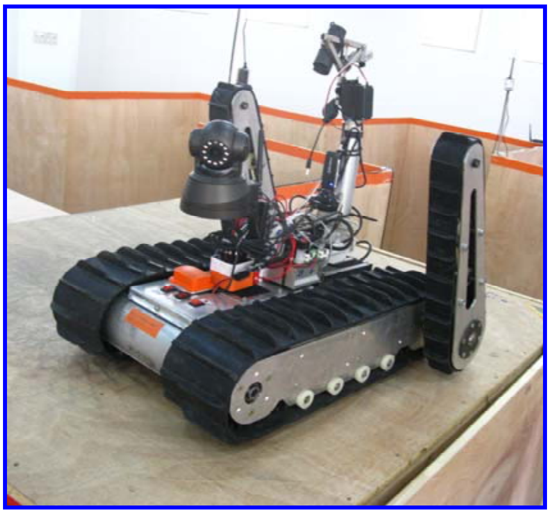

Fig. 2 Our current rescue robotβ

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4 Control Method and Human-Robot Interface

The hardware control system of robot β-II can be divided into 2 subsystems: robot and operator station. Fig.3 depicts the main control block diagram of robot β-II .

The robot is equipped with a notebook PC (HASEE W220S) as its onboard control PC. A pan-tilt-zoom camera (SONY EVI-D70P) is mounted on the robot as a main camera, two additional normal cameras are used for observing the environment and victims in several angles. A manipulator with 3DOF and a normal camera mounted on its top is installed, for getting close to victims and observing the situation clearly of them where the robot can't approach. Laser Range Finder (URG-04LX) is installed in front of robot for mapping the field explored. The chassis is the foundation of robot, its movement control hardware consists of DC motors, motor drivers and a microcontroller. The electrocircuit board is composed of DSP (TMS320F2812) and CPLD chip. These tracks are driven by motors (Maxon DC), in which there are encoders for the control of the speed and dead reckoning.

The β-II robot is a tele-operation robot. The communication between robot and operator station can be realized via wireless IEEE802.1a/b/g for control and map data transmission and RF for video stream transmission. Operator station consists of a notebook which is used to run the monitor software.

The operator use the main control of the robot based on notebook keyboard and a game joystick, with cameras and Laser Range Finder data to navigate to the disaster field. The user interface is progressed friendly and efficient. Operator can see real

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time video of the terrain in many angles and detect map which is automatically built from laser data the robot have collected.

We can package everything of the station for the robot operation in a suitcase and achieved quick set-up and break-down in the competition.

Our current proposal for the competition in China Open 2009 is to use the robot in essentially remote control mode. We are planning to incorporate the autonomous robot in yellow field this year.

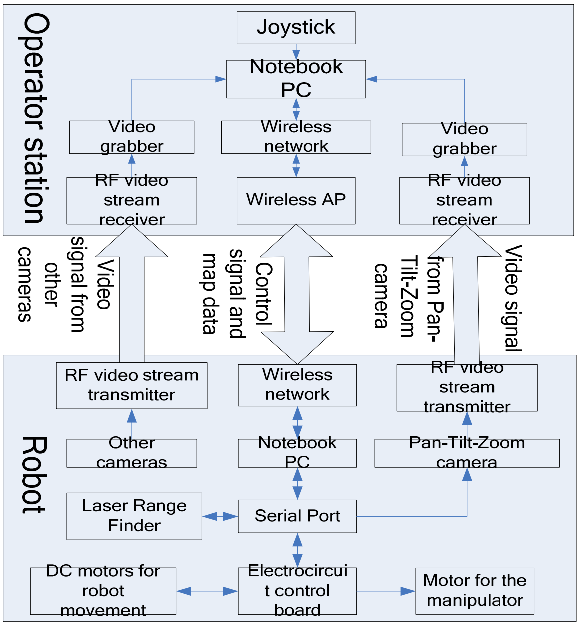

Fig. 3 The structure of control system.

5 Mapping Generation

Map building is a very important task for mobile robots. There are many methods for map building and the distinguished ones are the laser scan matching algorithm and the dead reckoning algorithm. Laser scans have several advantages such as amplely reflect the information of a environment, high sampling rate, excessive angular resolution, dense and accurate range measurement, as well as perfect range and distance resolution. The laser scan matching algorithm is better used for map building than that of the dead reckoning algorithm for the reason of its high precision.

The normal methods for scan matching can be divided into two types, feature based matching and point to point matching. The high match speed is the advantage of feature based matching, but the precision of this method is very low. By contririse, the point to point matching have a better precision but a lower speed.

To achieve the goal of building a perfect map in real time, we combined both of the two methods above and generated a new matching method which is derived from clustering algorithm in the domain of pattern recognition. We use the feature points in the two laser sacns to calculate and search for a rotation and translation parameters. This implementation makes the two laser scans approximately overlapped and easily to implement the next precision matching. Also, we use the corresponding points in the two laser scans to calculate another rotation and translation parameters. Then combine the two parameters and the matching is finally done. The new algorithm have a high matching precision as wel as a low matching speed and fit for real time and high precision map building.

From above, our matching algorithm is composed of two steps.

Step one, feature based matching. In this step we use the clustering algorithm to find appropriate rotation and translation parameters in the result-space of matching the feature points between the two scans. We use every two feature points between the two laser scans to calculate the rotation and translation parameters. All of the correct results are going to congregate around a point in the system of coordinate made up of the parameters and the right point stands for the appropriate parameters. Other false results will scatter in the coordinate randomly and usually single ones which are difficult to form clusters composed of multitudinous point elements.

Step two, point to point matching. In this section we use the ICP(iterative closet point) based algorithm to search precision rotation and translation parameters between the two laser scans. The least square function in the ICP algorithm has been improved for solving the problem of low speed convergence in the Apertrue-like problem in our new method.

Fig 4 shows the result of our method in China Open 2009.

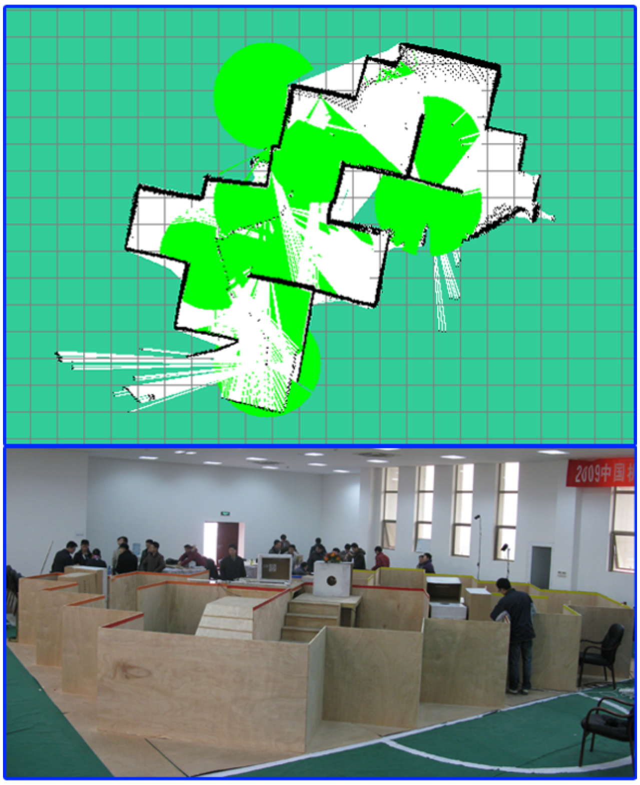

Fig. 4.map building in China Open 2009

6 WSN aided search and rescue

In real environment after natural or human induced disasters, collapsed buildings are common field environment for humanitarian search and rescue, which is too dangerous for rescuers to ingress. Autonomous robotic search and rescue system have been applied in practice, but it is difficult to track robots in collapsed buildings. As the low-cost wireless sensor networks mushroom in application, rescuers have introduced WSN to track mobile robots. Now our laboratory is trying in WSN aided rescue robot system, looking forward to applying it in RRL.

WSN is composed of many nodes with sensors you need. For nodes are distributed dispersedly, WSN can compute dispersedly, sense dispersedly and communicate among a large region. To track rescue robot, both the robot and the nodes must be equipped with wireless communication module and received signal strength indicator (RSSI). Using these devices we can measure the distances between

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nodes and robot, further, get the location of the robot with the locations of nodes. We have achieved in our simulation experiment based on USARSim.

Localization of robot involves in many items such as filtering of the noise and information fusion of multi-sensors. For example, signal strength attenuates in its broadcasting, which is sensitive to environment effect. The measurements of RSSI have great errors deviating from the real value. Without processing of the errors, estimated location of the robot will deviate greatly from real location. General speaking, Bayesian Filter, especially Particle Filter is one of the most popular method for above items. In our method, robot broadcasts its location first, then nodes that receive the broadcast can compute the distances between robot and nodes by received signal strength. At last we can fuse the measure information from these nodes by Bayesian Filter, eliminating effect of the noises among the state model and the observation model.

Besides benefit in tracking, there remain many other advantages of WSN. Firstly WSN facilitate the communication between operator and robots. If the point-to-point network between robot an operator doesn't work well, the video information and the victim information can transmit through the WSN, node by node. Secondly nodes can be equipped with the life detector. After one node detects a victim, the victim location can be transmitted to the robot through WSN. Simultaneously WSN can compute a optimal path for robot to approach victim. It will be much easier for robot to detect victim. Moreover nodes have great good effect on mapping. Node can sense the obstacle, dangerous region around it, and fusing sense information from all nodes, we can get a global map of the arena.

Now we are doing research in the simulation environment based on USARSim, and we will build a real environment for further research after having accumulated enough experience. The preparing work of building real environment has come into operation.

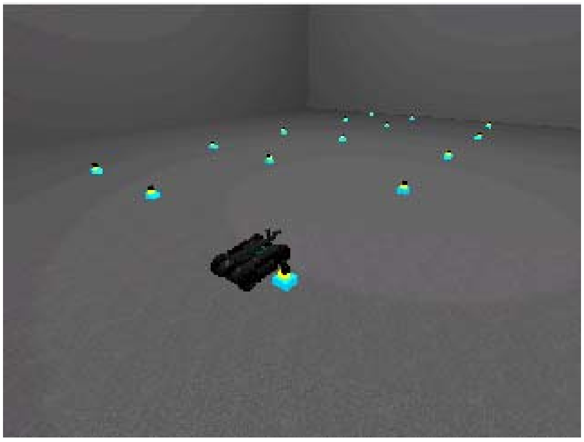

Fig. 5 Sensor network- robot system

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