RoboCupRescue 2010 - Robot League Team <Pelican United (JAPAN)>

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Abstract. This paper describes our team organization and our tracked vehicle 'Kenaf2' and Quince that are successors of our developed tracked vehicle with four sub-tracks such as TP07, Hibiscus, and Kenaf1. In this year, our team will compose of 3 sub-teams. The new robot "Kenaf2" and "Quince" hasve 6 DOF: a whole track body and four sub-tracks. They will be more stable, more powerful, and easier to operate in rubble. We've done much on-site training of our robot with people from fire depot, and found flaws to be improved. The Kenaf2 and Quince are the answer to it. We will also improve the ability of map construction, autonomy, and manipulation.

Introduction

This paper describes our team organization and our tracked vehicle 'Kenaf2' and 'Quince' that are successors of our developed tracked vehicles with four sub-tracks such as TP07, Hibiscus, and Kenaf [1]. In this year, our team will compose of 3 sub-teams: Chiba Institute of Technology, Tohoku University and AIST. The new robot "Kenaf2" and "Quince" have 6 DOF: a whole track body and four sub-tracks. It will be more stable, more powerful, and easier to operate in rubble. We've done much on-site training of our robot with people from fire depot, and found flaws to be improved. The Kenaf2 and Quince is the answer to it. We will also improve the ability of map construction, autonomy, and manipulation. The details of autonomous system and multi robot mapping are described in [5].

1. Team Members and Their Contributions

Our team "Pelican United" is organized with members from Tohoku University, Chiba Institute of Technology, and Advanced Industrial Science and Technology.

2.	Eiji Koyanagi	Mechanical design
3.	Itsuki Noda	Integration of sensing information into GIS
4.	Keiji Nagatani	High level locomotion command system
5.	Satoshi Tadokoro	Adviser
6.	Kazunori Ohno	3D mapping and autonomous control algorithm
7.	Tomoaki Yoshida	System and Software architecture design
8.	Eric Rohmer	Automatic sub-tracks control algorithm
9.	Naoki Miyahara	Automatic sub-crawler control algorithm
10.	Yasushi Hata	3-D mapping and recognition
11.	Masashi Yamazaki	Autonomous control algorithm
12.	Ken Sakurada	3-D mapping and localization
13.	Eijiro Takeuchi	Multi-robots SLAM
14.	Seiga Kiribayashi	Mechanisms assembly and operator
15.	Hidehisa Akiyama	Integration of sensing information into GIS
16.	Student member	Autonomous control algorithm
17.	Student member	Mechanisms assembly
18.	Student member	Mechanisms assembly
19.	Ikuko Tanimura	Travel and Video Support

20. Operator Station Set-up and Break-Down (10 minutes)

The operator station is packed in one middle size Pelican case, and the robot is also packed in two middle size Pelican cases. Total weight will not exceed 150kg, and considering that the pelican cases are equipped with wheels and handles, it is possible to carry by one person.

Most time consuming step of the set-up process in the operator station is to boot up the PCs , and establish wireless connection between the station and the robot. We will save a map data as some electrical data, and will submit it. It is easy for Robocup stuffs to share the victim's information.

We will plan that the number of operator is only one. The operator will control some robots during the competition.

21. Communications

22. We use IEEE 802.11a (5.2GHz Band) for both control and sensing (including video, Laser Ranger Finder etc) communications. In Japan, all WLAN RF power is restricted to 10mW. Therefore our robots and operator station are also use 10mW of RF power.
23.

Rescue Robot League		
Pelican United (Japan)		
MODIFY TABLE TO NOTE ALL FREQENCIES THAT APPLY TO YOUR TEAM		
Frequency	**Channel/Band**	**Power (mW)**
5.0 GHz - 802.11a	36-64	10mW
2.4 GHz - 802.11b/g		
2.4 GHz - Bluetooth	-	
2.4 GHz - Other	-	
1.2 GHz	-	
900 MHz	-	
40 MHz	-	
27 MHz	-	

24.

25. Control Method and Human-Robot Interface

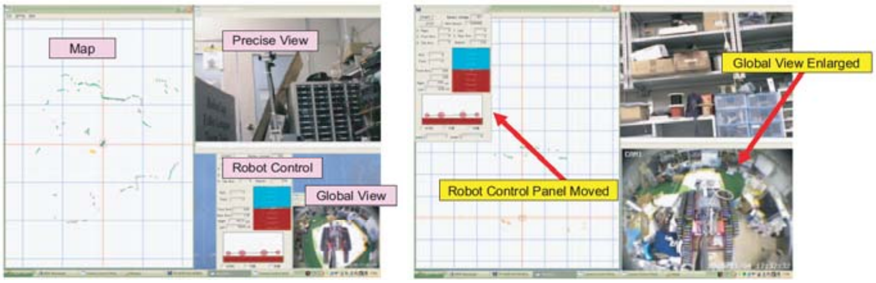
Please use this section to describe your plan for controlling your robot [remote teleoperation, partial autonomy, full autonomy], and your human-robot interface for robot control and victim recognition.. Also explain what your operator will be doing during missions and which tasks are autonomous.

We will control our tracked vehicles in remote tele-operation and full autonomy. For tele-operation, the locomotion of the robot is controlled with single popular joypad equipped with 2 analog stick and 12 digital bottoms. The operator recognizes a surrounding environment of the robot trough video information of a bird view camera, and range data from laser range scanners. With the baseline system, all decisions should be made by the operator

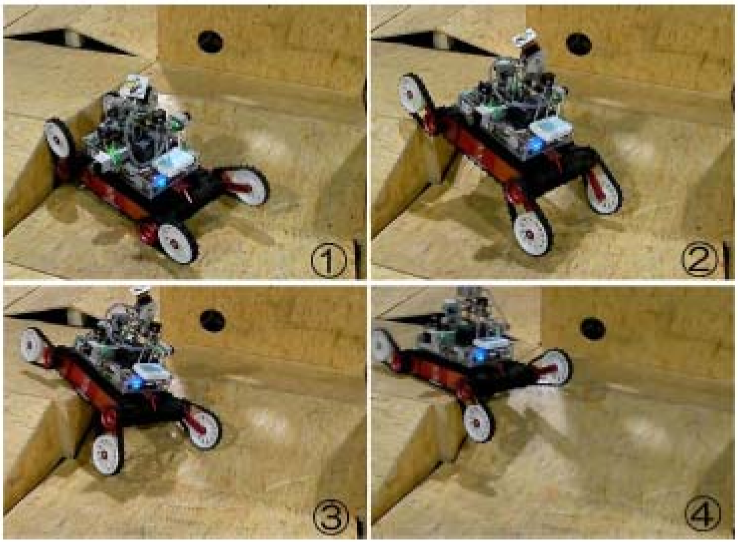
A pan-tilt-zoom camera on the robot will be controlled using touch panel on the video display. The touch panel seems very handy than usual pointing device such as mouse or trackball, especially when the operator is not sit down on a chair.

Information expected to be shown such as video from several cameras, range data, gradient sensor readings, is too much for single LCD panel. We organize this information fit with two LCD panel, and built such operator station.

In addition, we are working on autonomous control of sub-tracks and autonomous exploration system. These autonomous robots will build maps using 3-D laser scanner and find victims using a thermal camera. We will use these new technologies on the RoboCupRescue competition.



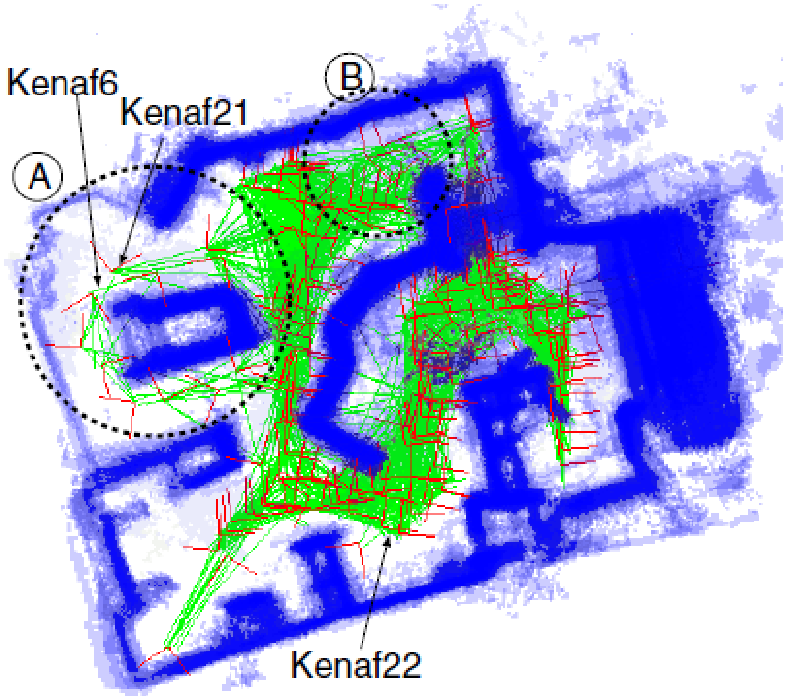
An Example Layout of Our Control Interface: Layout can
be changed for the situation (Search or Control).



Snapshot of autonomous sub-tracks control

26. Map generation/printing

The robots can measure 3-D shape using a 3-D laser scanners or one fixed 2-D laser scanner. Using range data from such laser scanners and robot's position and posture estimated from odometry and IMU such as gyro sensors and gradient sensors, our robots will build a semi-automatic 2D/3D hybrid map(2D SLAM with 3D range data). In last RoboCupRescue competition, we tried to build such multi-robot SLAM. It works well in basic experiment. However, it did not work in real competition. We will improve our method and build maps.



Multi-Robot SLAM result in our test field: We can build a large map combining three robot scan data.

27. Sensors for Navigation and Localization

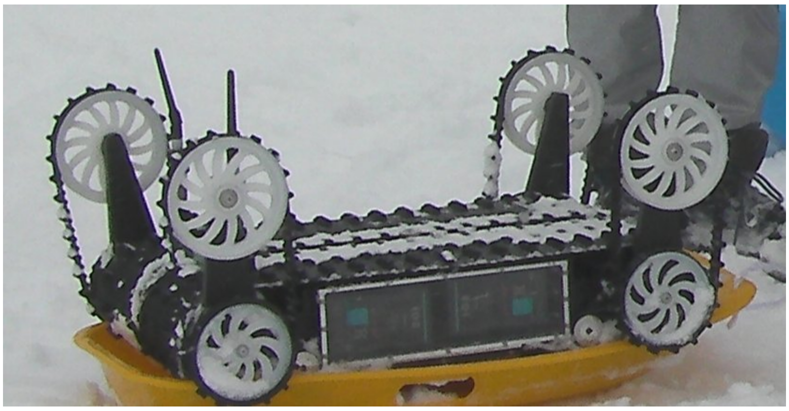
We will use gyro-based odometry for position estimation. For odometry based navigation, each motor is equipped with incremental encoder. Also, 3-axis gyro sensor, 3-axis gravity sensor are placed inside the robot. To compensate odometory error, 2D SLAM will be performed beside with manual compensation by the operator himself. To recognize environment by the operator, a bird-view camera, and pan-tilt-zoom camera is used. The configuration of these cameras is almost same as last year model.

28. Sensors for Victim Identification

A pan-tilt-zoom camera is used for victim identification. For supplemental use, a thermal camera and CO_2 sensor are also mounted on top of the robot. Bi-directional audio communication will be implemented until the competition.

29. Robot Locomotion

The robot is equipped with 2 full-body tracks and 4 sub-tracks for locomotion. We recognize the problem with last year model, and re-design to improve mobility on rough terrain. Main improvements are as follows: Powerful motors are used for locomotion. The center of gravity of Kenaf2 is lower than one of Kenaf. Material of Crawler is changed new one. The new model of our robot should work better than kenaf, “which is winner of 2007 RoboCupRescue mobility competition”, on step fields. In addition, we are building new tracked vehicle “Quince”. The difference between Quince and Kenaf is wide body for increasing stability.



Kenaf and Quince: 6DOF Tracked Vehicle with Sub-tracks

30. Other Mechanisms

The structure of our robot is designed the maintenance task in mind. We use safe and powerful batteries for the Kenaf2, which can be carried by airplane.

31. Team Training for Operation (Human Factors)

Our operator is trained on the training facility of fire depot periodically. In such event, volunteers from fire depot also operate our robot. They operate our robot well, with a few minutes instruction. The fact shows our robot requires almost no training to operate.

32. Possibility for Practical Application to Real Disaster Site

We've already used a base model of our robot on the site at the Mid Niigata Prefecture Earthquake in 2004. Our robot was used to check damages of underground pipe from inside of it.

33. System Cost

Now, we sell base system of Kenaf2 at about $22000(US) for Japanese researchers in JAPAN, because the system is still improved in our team, and we can only support them in Japanese. However, we are making Kenaf2 Quince with a Japanese company as product. We are planning to sell the Kenaf2 and Quince at cheaper price in the world.

34. Lessons Learned

In the last competition, we modified our hardware and software for the debug and the improvement. We think that the our robot will change according to the field and the rules during the competition. Especially, software will change drastically because the rules often change during the competition.

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