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RoboCupRescue - Robot League Team Tiny Seekers (Japan)

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Abstract. The function which forms a map automatically is indispensable to the practical rescue robot. This time, We do the localization of the robot by using the ESPAR antenna which can detect the arrival direction of the electric wave. We will automate the formation of the map as much as possible. And, we make software so that it can input landmark by the manual operation to make reading of the map easy. We will use a quadrupedal walking robot and a wheel-type robot. We do a search by the remote control by using the quadrupedal walking robot. And, we try a semiautomatic search by using the wheel-type robot.

Introduction

This time, we prepared for two robots. One is a remote controled quadrupedal walking robot(Fig.1). Another is a semiautomatic wheel-type robot(Fig.2). We think that a practical rescue robot must have the function which forms the map which wrote the conditions of the suffering spot and a sufferer's position automatically. Otherwise, the operator of the robot can't be concentrated on the sufferer's search work. As for the actual rescue activities, we must use the robot which an operator shouldn't be as necessary as possible more. The function which forms a map automatically is indispensable to the automation of the search work.

However, we take the size of the robot and mobility seriously, too. So, we prepared for the miniature robot that it moved quickly by the remote control(Fig.1). And, we prepared for the medium-sized robot that the miniature PC to search a sufferer as automatically as possible was carried.(Fig.2).

We are calling the robot of Fig.1 "4Legs". It participated in the RoboCup Japan open 2004 rescue robot league, and this robot was the 3rd prize.[2]

We are calling the robot of Fig.2 "VAIONEER". We composed this robot by PIONEER (AAAI company robot) and the miniature computer VAIO(SONY).The camera of VAIONEER will be mounted on the TPZ camera platform. The program which looks for an image in the image from the camera like a sufferer is run on the PC of VAIONEER. VAIONEER measures temperature of the doubtful position by the non-contact type thermometer, and distinguishes the matter whether it is a sufferer, and reports a result to the operator.

We composed a localization system by the ESPAR antenna[1] for the localization of the robot(Fig.3). We are building the system which records the movement course of the robot from the robot position information. We will include the function which adds landmark and sufferer information to the system during building. We are adjusting a system so that it can add information from VIONEER to the map.

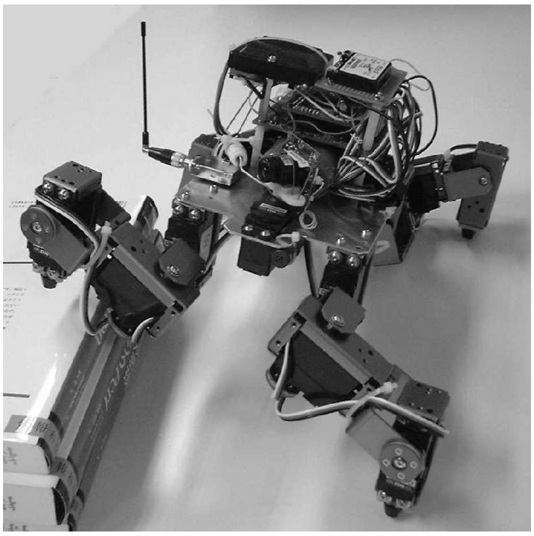

Fig.1 A Quadrupedal walking robot "4Legs"

Fig.2 A wheel-type robot "VAIONEER"

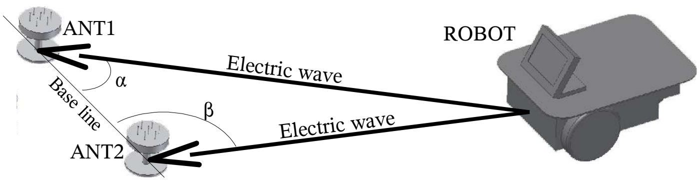

Fig.3 The schematic diagram of the localization by two ESPAR antennas

Angle α and β given by ANT1 and ANT2 against to the baseline between ANT1 and ANT2 tell the location of the robot.

Table 1. Specifications of 4Legs

Built in CPU	SH2(7145F) 48MHz 3.3V
Servo Motor	KRS-2346ICS (KONDO) X 13
Frame	ServoCreation type KO (ITO RAINETSU) X 12
Wireless Modem	FRH-SD07T (FUTABA)
TV Transmitter	PG100 1.2GHz 12V
Camera	MTV-54B0N 12V
Power Source	7.2V NiCd(6Cells) X 1
Weight	About 2000g (include battery)
Size	280mm X 320mm(Front-Back X Side) At Neutral Pose (H Shape) height : 160mm – 210mm (190mm At Starting)
Moving speed	Max : 30cm/s , Cruising : 15cm/s

Table 2. Specifications of VAIONEER

CPU 1	SH2(7145F) 48MHz 3.3V (To control motor)
CPU 2	VAIO Type U (To commnunicate)
Weight	About 7kg (include batteries)
Size	450mm X 350mm(Front-Back X Side) hegiht : 300mm
Moving Speed	10 cm/s

1. Team Members and Their Contributions

We describe our team member here. This list is very temporary..

- Team Leader: Masaru Shimizu
- Operator: Masaru Shimizu
- Mechanical design: Masaru Shimizu
- Controller development: Masaru Shimizu

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

We devised these methods shown in the following to do a setup or a breakdown in ten minutes. This time, we use at least two robots. But, only one computer will be used for the one for the console. Therefore, this move work can be simplified by using a notebook PC. After all, our main devices are a notebook PC, two joy sticks, a miniature printer and an ESPAR antenna array. We think that it takes time for the establishment of the ESPAR antenna array. We must do some calibration to improve the precision of the localization.

Even if a difficulty is entailed, we are expecting that the start of the system is completed by the training within eight minutes.

Our breakdown will be practiced so that it may be completed in about five minutes.

3. Communications

We must use a wireless device for 2.4 GHz because the ESPAR antenna being used for the localization system exists for only 2.4 GHz.

As for the AV transmitter for 4Legs, we could not look for a device for 5 GHz. Then, we will use a device for 1.2 GHz.

As for the communication for VAIONIEER, we consider changing all communication except for the localization to the device for 5 GHz.

Table 3. Radio frequency

Rescue Robot League		
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MODIFY TABLE TO NOTE ALL FREQENCIES THAT APPLY TO YOUR TEAM		
Frequency	**Channel/Band**	**Power (mW)**
5.0 GHz - 802.11a	Follow direction	2.5 mW/MHz
2.4 GHz (WireLess Modem)	Follow direction	5 mW/MHz
1.2 GHz (For AV Transmitter)	Selectable from 1080, 1120, 1160, 1200MHz	100mW (We are looking for low power one)

4. Control Method and Human-Robot Interface

We describe the control method and the human robot interface of each robot in this chapter.

4. 1 In case of VAIONEER

An operator indicates a proceeding direction to VAIONEER by the joy stick with seeing an image from VAIONEER on the screen of the notebook PC. VAIONEER is moved in the direction where it was indicated with avoiding an obstacle automatically.

VAIONEER scans a sufferer by the infrared rays sensor during the movement. When a sufferer is discovered, an operator confirms a sufferer by the sensor (in such cases as the sound sensor, the temperature sensor and the CO2 sensor). We will make a localization system that it can record the path of VAIONEER automatically. And, we will add the function that an operator can add a sufferer's icon to that map.

Fig4 is a program execution screen on the operator side. This program is the server software to do the transfer of the image and the control of the robot via LAN. We add the indication of the sensor to this program.

Fig5 is a program execution screen on the VAIONEER side. This program is the client software to do the transfer of the image and the control of the robot via LAN. We equipped this program with the indication of the emergency shut down button and the battery indicator.

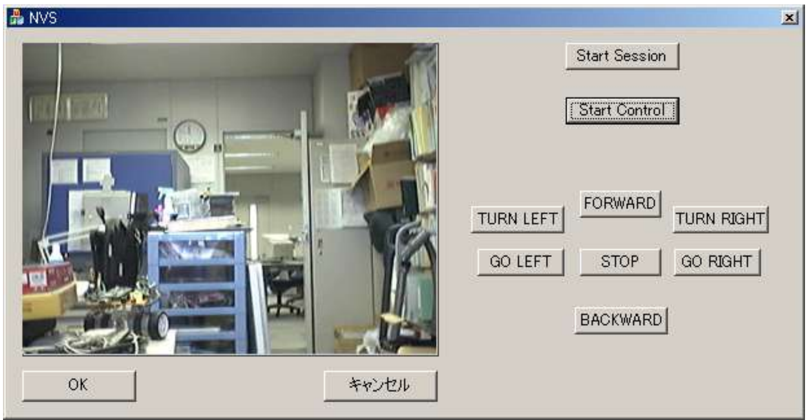

Fig. 4 A VAIONEER control software executive screen on the console side

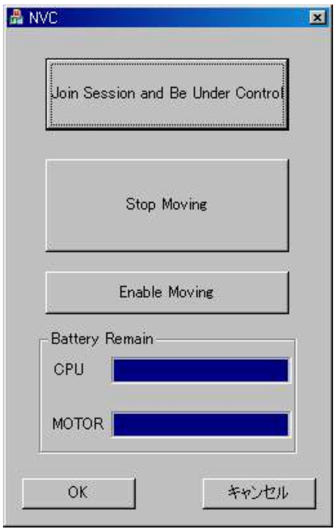

Fig. 5 A control software executive screen on the VAIONEER side

4. 2 In case of 4Legs

An operator operates 4Legs by using the joy stick or the keyboard. A video image from 4Legs is captured by the notebook PC and indicated. 4Legs avoids an easy obstacle automatically by the sensor. Therefore, an operator can be concentrated on the investigation activities.

4Legs equips four infrared rays sensors. 4Legs sends a signal to the operator when there is a sufferer who radiates infrared rays near 4Legs. When a sufferer is discovered, an operator confirms a sufferer by the sensor (in such cases as the sound sensor, the temperature sensor and the CO2 sensor).

We will make a localization system that it can record the path of 4Legs automatically as well as the case of VAIONEER. We only add an icon to the map, and we will be able to make a map for the presentation.

5. Map generation/printing

We will build a localization system (Fig.3) by the ESPAR antennas, and we will do the localization of the robots. An ESPAR antenna has the function which controls directivity in transmission and reception of the electric wave electronically. First, we use this function, and look for the direction of the robot which is a source of electric wave sending. We carry this out with two and more ESPAR antenna. Next, we calculate the position of the robot by the method of the triangular surveying.

And we will record the position of the robots, and make the path map of the robots. When a sufferer is discovered, we add a sufferer's icon to the map in the position to discover a sufferer by the manual operation. We will stick the icons of the walls, the furniture and the obstacles along the path of the robots.

Our map will be a bitmap image, and it will be printed with a miniature printer.

6. Sensors for Navigation and Localization

6. 1 Sensors for Navigation

VAIONEER equips a USB camera and a gyroscope sensor and distance sensors, infrared rays sensors, a CO2 sensor, a temperature sensor and a sound sensor. We will fix a USB camera on the camera platform (2 degree of freedom). (Fig.6) We can see the surroundings of VAIONEER by this device. We finally calculate the direction of the camera by using the gyroscope sensor. The direction of the camera should be necessary by the automatic preparation of the map. A distance sensor is for the obstacle avoidance. This distance sensor can examine the distance of 10cm-80 cm. Four distance sensors are installed on the surroundings of VAIONEER.

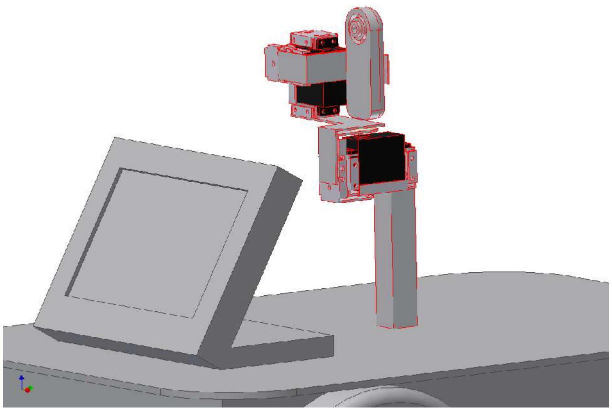

Fig. 6 USB Camera and Camera Platform(2 D.O.F.).

4Legs will equip a CCD camera and a gyroscope sensor and distance sensors, infrared rays sensors, a CO2 sensor, a temperature sensor and a sound sensor. A CCD camera transmits the sight of the robot to the operator with an AV transmitter.

A distance sensor is for the obstacle avoidance.

6. 2 Sensors for Localization

Our system does the localization of the robots by using the ESPAR antenna. (Fig.7)

An ESPAR antenna is the device which can acquire the direction of a source of electric wave sending. When two and more ESPAR antenna is combined, we can calculate the position of the robot by the triangular surveying. We illustrate a localization system by three ESPAR antennas for the localization of the three-dimensional coordinate with Fig.7.

2.4GHz is used with the position detection system which used ESPAR antennas. We use the radio of the remote control of 4Legs for the localization as well in case of 4Legs. The radio of the remote control of VAIONEER is not 2.4GHz in case of VAIONEER. So, we equip VAIONEER with the wireless tag (Fig.8) of our own work, and cope with a localization.

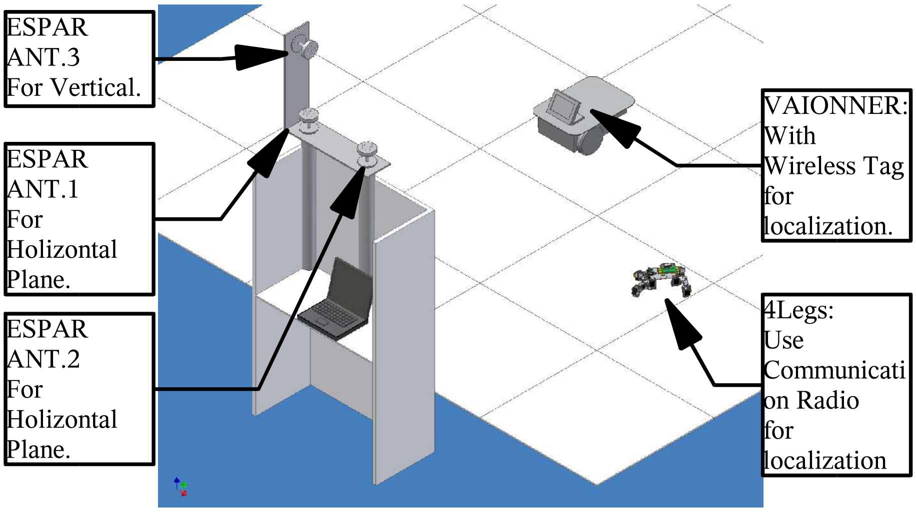

Fig. 7 Localization with 3 ESPAR antennas (and the wireless tag).

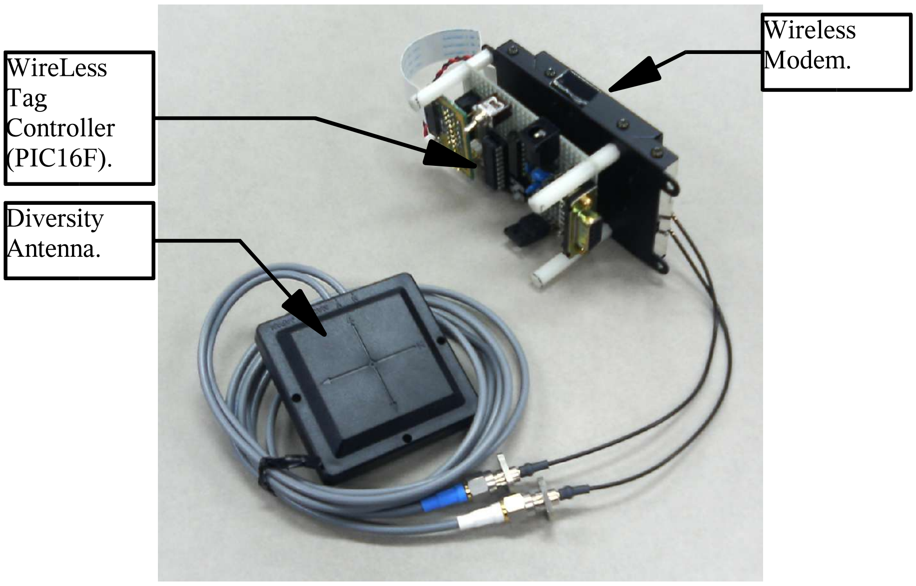

Fig. 8 Wireless Tag For VAIONEER

7. Sensors for Victim Identification

The first sensor to detect a victim is a camera with our system. Because there is an infrared rays sensor in our system, it has the possibility which can be sensed when it passes beside the sufferer who overlooked it with a camera. It is said that a temperature sensor, a sound sensor and a CO2 sensor are effective as a sensor generally to distinguish a sufferer. A temperature sensor and a sound sensor will be equipped with our system. If it is possible, a CO2 sensor is equipped, too.

8. Robot Locomotion

8. 1 Locomotion for VAIONEER

The movement mechanism of VAIONEER is composed of two driving wheels and one caster. It is a movement mechanism by typical wheel running.

8. 2 Locomotion for 4Legs

The movement mechanism of 4Legs is composed of four feet which have 3 degree of freedom(Fig.9). These feet move a robot by repeating a simple pattern due to the open loop. Because algorithm is simple, a foot can be moved quickly. The top speed of 4Legs is 30 cm/s. Cruising speed is 15 cm/s.

About 4Legs, we think a movement mechanism in the vertical direction.

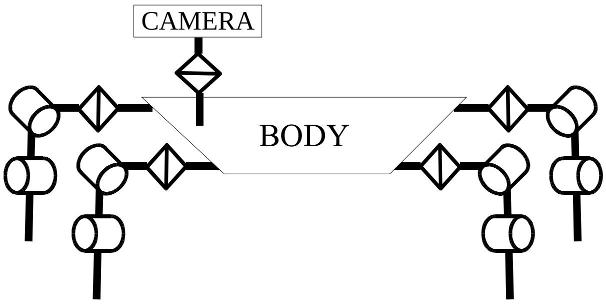

Fig. 9 4Legs DOF diagram

9. Other Mechanisms

We are making a thin camera robot like a viewing tube.

This robot is composed of the super-miniature camera, the miniature motor and miniature crawler. This camera robot will be equipped as a child machine of VAIONEER. This robot searches the inside of the debris instead of VAIONEER. VAION-

EER reels the cable of this robot, and collects these camera robots from the inside of the debris.

We are thinking about the device for 4Legs to be moved in the vertical direction, too.

10. Team Training for Operation (Human Factors)

The efficiency of the rescue is bad even if the automation of the robot proceeds when a human judgment is improper.

So, we will do the following practice.

1. The practice to look for a suitable search area in the inside of the unfinished map.
2. The practice to search for the sufferer inside the search area efficiently.
3. The practice to ascertain conditions to fall into the movement impossibility.
4. The practice to get out of the trap.

11. Possibility for Practical Application to Real Disaster Site

We think that the rescue robot handled in the actual disaster spot must have the performance which resists water, dust, oil, a shock and high temperature. And, miniaturization is required with the robot to be included in the inside of the debris, too.

We are thinking about the development of the miniature robot which looks like 4Legs.

12. System Cost

We will clear the cost of our system in this chapter.

TOTAL SYSTEM COST (4Legs): 215,320yen (at least)

KEY PART NAME:	Digital Servo
PART NUMBER:	KRS-2346ICS
MANUFACTURER:	KONDO
COST:	10,000yen X 13 = 130,000 yen
WEBSITE:	http://www.kondo-robot.com/
DESCRIPTION/TIPS:	The servomotors of 4Legs. We can control this servo with PWM signal.

KEY PART NAME:	ServoCreation type KO 6set
PART NUMBER:	SCT-01K06
MANUFACTURER:	Ito Reinetu Corp.
COST:	20,160yen X 2 = 40,320yen
WEBSITE:	http://www.i-rt.co.jp/
DESCRIPTION/TIPS:	SCT-01K06 is 6 set of servo brackets.

KEY PART NAME:	Wireless Modem
PART NUMBER:	FRH-SD07T
MANUFACTURER:	FUTABA
COST:	45,000yen
WEBSITE:	http://www.futaba.co.jp/
DESCRIPTION/TIPS:	2.4GHz Wireless Modem. The interface is RS232C.

TOTAL SYSTEM COST (VAIONEER): 520,000yen (at least)

KEY PART NAME:	PIONEER 1
PART NUMBER:	
MANUFACTURER:	AAI
COST:	270,000yen
WEBSITE:	http://www.aai.jp/
DESCRIPTION/TIPS:	VAIONEER body parts.

KEY PART NAME:	VAIO TypeU
PART NUMBER:	VGN-U70P
MANUFACTURER:	Sony
COST:	250,000yen
WEBSITE:	http://www.sony.jp/
DESCRIPTION/TIPS:	

References

1. T. Akiyama, K. Inagaki, T. Ohira, and M. Hikita:Two-dimensional optical signal-processing beamformer using multilayer polymetric optical waveguide arrays, IEEE Trans. Microwave Theory Tech., MTT-49, 10, pp.2055-2061, Oct. 2001

References on the web

2. http://www.rescuesystem.org/robocuprescue/japan2004/japan2004.html