RoboCupRescue 2011 - Robot League Team <SHINOBI (JAPAN)>

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Abstract. We will participate this competition with two robots. First robot is KOHGA3. KOHGA3 is 2nd place of Best-in-class in mobility in 2007 and 3rd place of Best -in-class mobility in 2009. Third one is HIEI. HIEI is autonomous searching robot has 2-flippers at its rear. This one will be used in both red arena (tel-operation) and yellow arena (autonomy).

Introduction

We have participated RoboCupRescue competitions since 2002. Our results are;

- 2002 International (Fukuoka): 2nd place,
- 2003 Japan Open (Niigata): 2nd place,
- 2003 International (Padova): Semi Final,
- 2004 Japan Open (Osaka): 1st place,
- 2004 International (Lisbon): 5th place,
- 2005 International (Osaka): Semi Final, Best Design Award 1st place,
- 2006 Japan Open (Kitakyusyu): 4th place,
- 2006 International (Bremen): Locomotion Challenge 1st place.
- 2007 Japan Open (Osaka): 2th place
- 2007 International (Atlanta): 6th place, Best-in-class in mobility 2st place.
- 2009 Japan Open (Osaka):1st Place,
- 2009 International (Graz):4th Place, Best-in-class in mobility 3rd place.
- 2010 Japan Open (Osaka):3rd Place,
- 2010 Thailand Rescue Robot Championship (Bangkok): Best Autonomous Award

We have put our experience at these competitions to accout for our research. For example, we proposed “synthsezed seen recollection [1] (Fig. 1)”, “pole fish-eye camera [2]” and “better ratio of the number of operators to the number of robots [3].”

Since JapanOpen2007 competition, we have challenged to develop both mobility robots and full-autonomous robots.

We developed KOHGA2, our first robot, which is the winner of Locomotion Challenge in 2006. KOHGA2 is a reconfigurable robot. We can freely change its configuration in advance suitable for environments. In fig.2, KOHGA2 have 3 bodies, two 2-DOF joints and 6 crawler arms. This configuration is useful to overcome stack situations. In Fig3, KOHGA2 has 1 body and 4 crawler arms. This configuration is useful for running on rubbles. With this configuration, we won the Locomotion Challenge in 2006.

However KOHGA2 is broken down easily but can not be maintained easily because the mechanism of KOHGA2 is complex. We developed KOHGA3 (Fig.4), our second robot, which was simplified on the mechanism. KOHGA3 was more reliability than KOHGA2.

HIEI(Fig. 5), our third robot, has 2-flipper at its rear and full autonomous robot. This robot can build 2D map real-time by SLAM (ICP) algorism(Chapter 4, 5) and find victims using thermal camera automatically (Chapter 7).

Fig. 1 (a): actual camera images; (b) synthesized images from past camera image data and then the robot position information. Images at each row in (a) and (b) are images at the same time stamps.

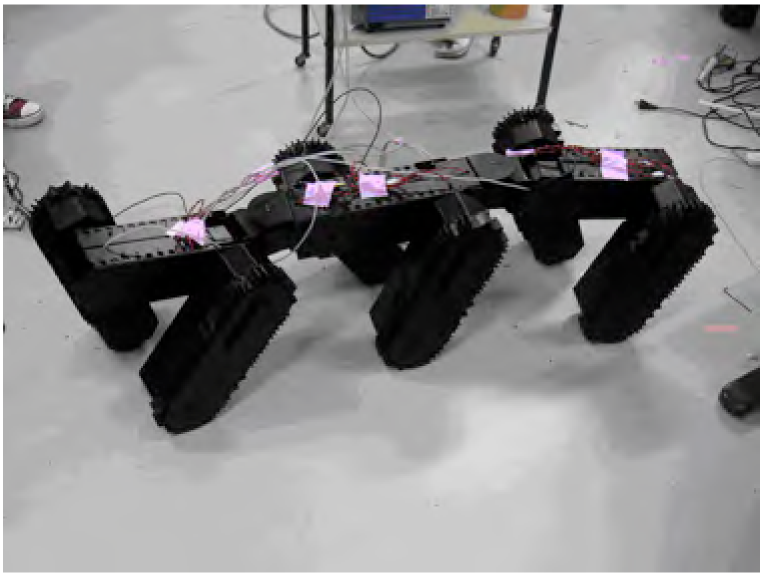


Fig. 2 KOHGA2 (3 bodies and 6 crawler arms)

Fig. 3 KOHGA2 (1 bodies and 4 crawler arms)

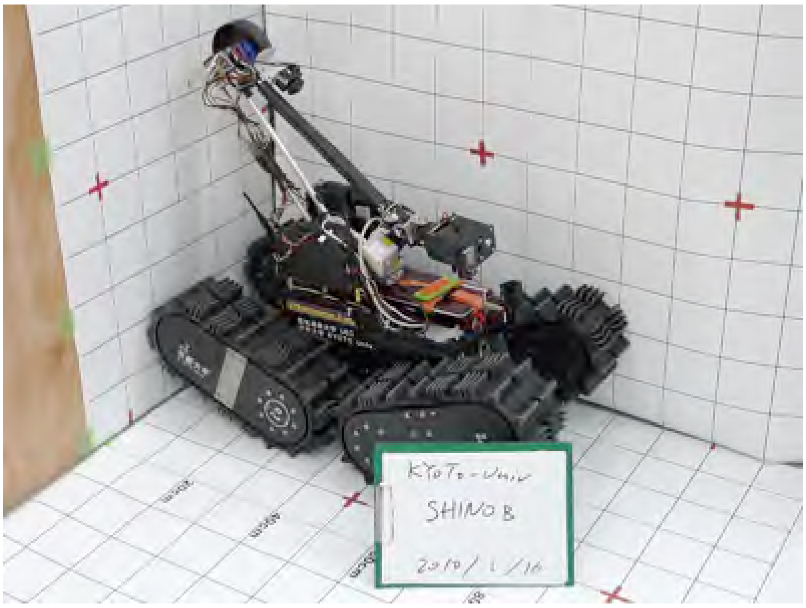


Fig. 4 KOHGA3 (1 bodies and 4 crawler arms)

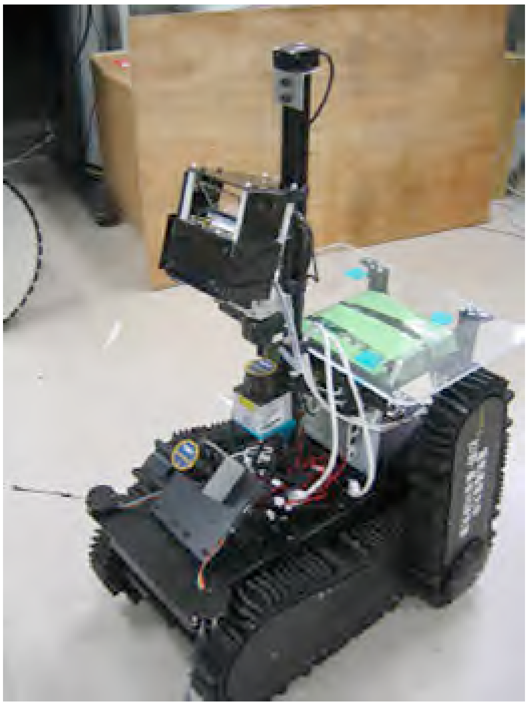


Fig. 5 HIEI(2-flipper at its rear and full autonomous robot)

1. Team Members and Their Contributions

- Yuichi Ambe — Team leader, KOHGA3 system development
- Hisashi Mizumoto — KOHGA3, HIEI system development
- Hayato Shin — KOHGA3 system development
- Ryo Ariizumi — KOHGA3 system development
- Tehyon Kim — HIEI system development
- Souhei Hanamoto — HIEI system development
- Satoshi Toyoshima — KOHGA3 system development
- Hiroki Igarashi — Mechanical design advisor
- Fumitoshi Matsuno — General advisor

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

We have participated in several rescue robot competitions and have many experiences of operator station set-up and break-down. In 2007, we packaged everything which we need for the robot operation in one suitcase(Fig.6), and could achieve quick set-up and break-down. We will use this system again at this competition.

However, we prepared one control box per one robot, then it took much time on set-up and break-down for all robots. We will develop only one control box for three robots for RoboCup2008.

Fig.6 we packaged everything we need for the robot operation in one suitcase

3. Communications

We will use the wireless LAN. The frequency and the channel are shown in following table.

Rescue Robot League		
SHINOBI (JAPAN)		
MODIFY TABLE TO NOTE ALL FREQENCIES THAT APPLY TO YOUR TEAM		
Frequency	**Channel/Band**	**Power (mW)**
5.0 GHz - 802.11a	36, 40, 44, 48 (selectable)	
5.0 GHz - 802.11a	36, 40, 44, 48 (selectable)	
5.0 GHz - 802.11a	36, 40, 44, 48 (selectable)	

4. Control Method and Human-Robot Interface

Our robots control methods are as follows.

KOHGA3: teleoperation.

HIEI: teleoperation / full autonomy (selectable).

5. Map generation/printing

An automatic 2-D map building method by laser range finder (LRF) have implemented on the HIEI (Fig.7;left side). We will extend this 2-D map building method to 3-D one by rotating the LRF for 3-D point scanning. With this method we can also obtain good robot position information. The 3D map by this method (Fig.8) have implemented on the FUMA, which is developed for robocup 2004 and 2005.

We develop the automatic victim sheet print software for KOHGA2 and KOHGA3(Fig. 9). During the mission, the operator selects the some buttons and fills the text field on the interface software about the information of victims. After the mission, if the operator does only one click on “print” button, all victim data sheets are printed automatically.

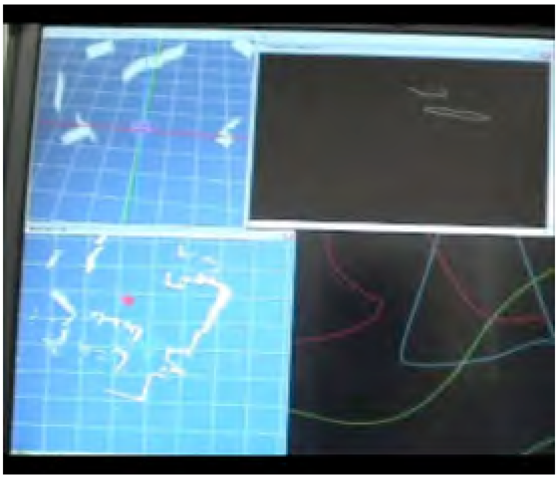


Fig. 7 human-robot interface for HIEI. Up-left; wall image based on lazar rangefinder. Up-right; the area enclosed with white line is high temperature area by thermal camera. Low-left; generated 2D map of the environment.

Fig.8 3DMAP; you can find stand human on the center the image

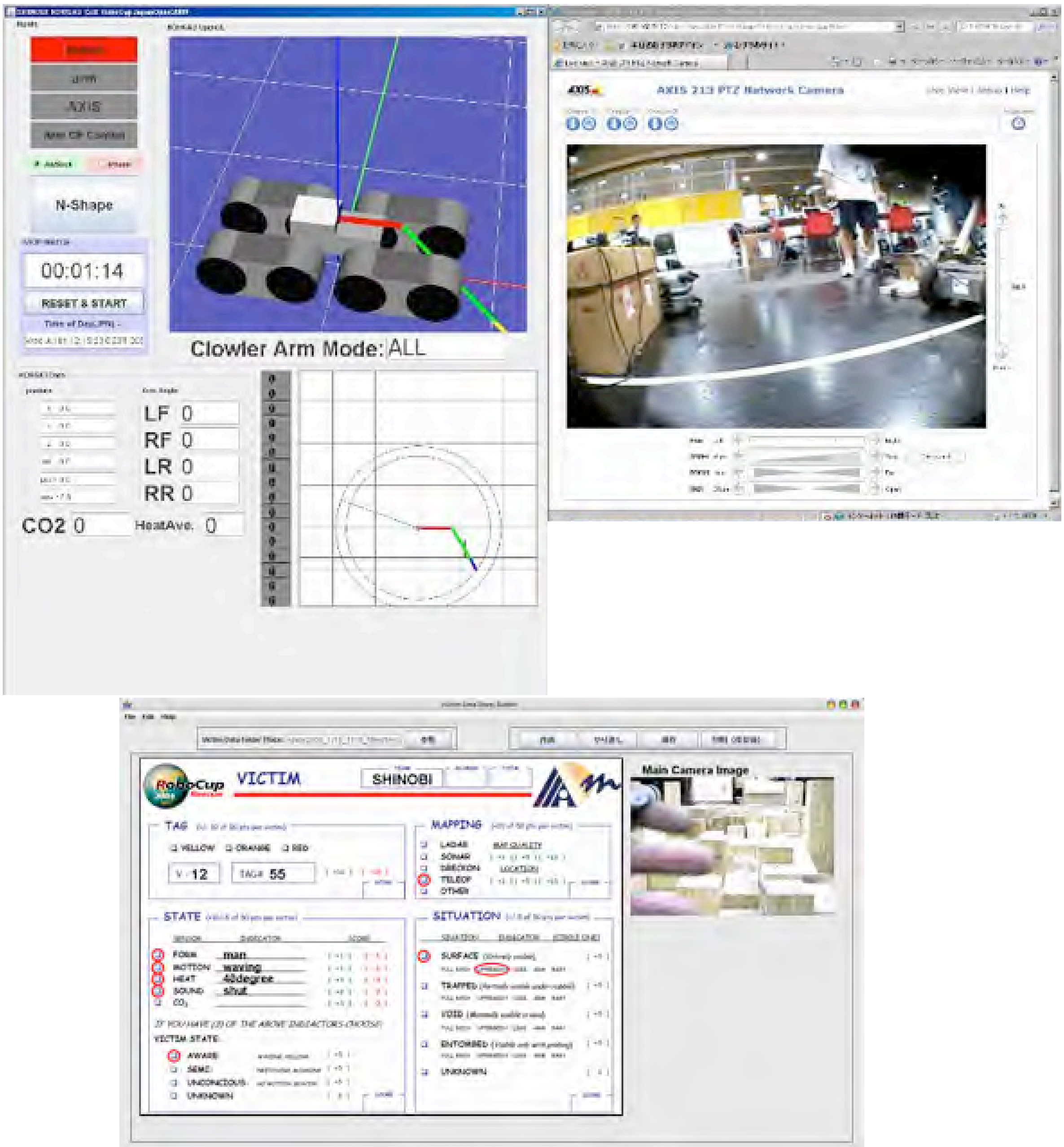


Fig. 9 automatic victim sheet print software (upper: input interface lower: output interface)

6. Sensors for Navigation and Localization

We use following sensors for navigation and localization.

Fish-Eye Camera: for understanding the surroundings of the robot
LRF(URG, HOKUYO): for SLAM (Simultaneous Localization and Mapping)
Encoder: for getting the robot velocity.
Inertial Cube3: for getting the robot angle.

7. Sensors for Victim Identification

We use following sensors for victim identification.

CCD camera or web camera: form and move
Thermal camera: heat
CO2 gas sensor: breath
Speaker and microphone: sound and consciousness

We overlay the thermal camera image to the normal CCD camera image in order to ease to recognize victims for the operator (Fig. 11). The high temperature area displayed as the area enclosed with white line (Fig.12).

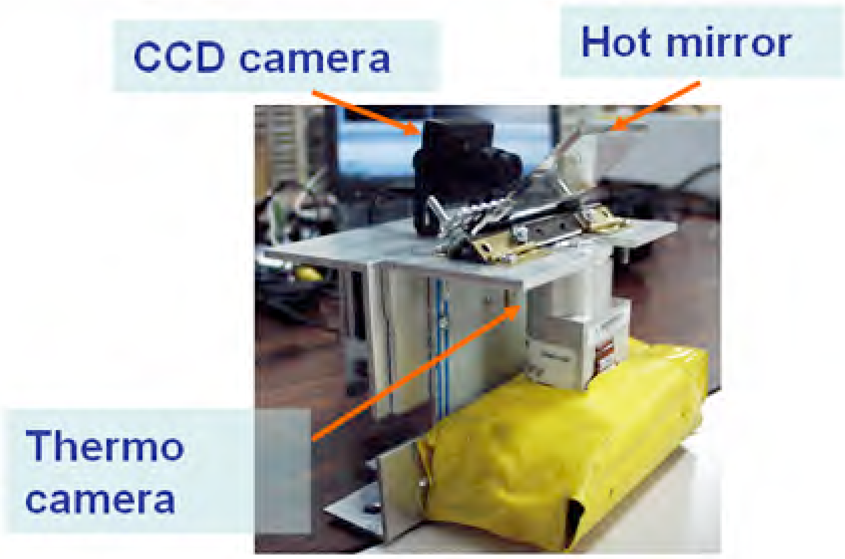


Fig. 11 Thermal camera devise
(overlay thermal camera image to normal CCD camera image)

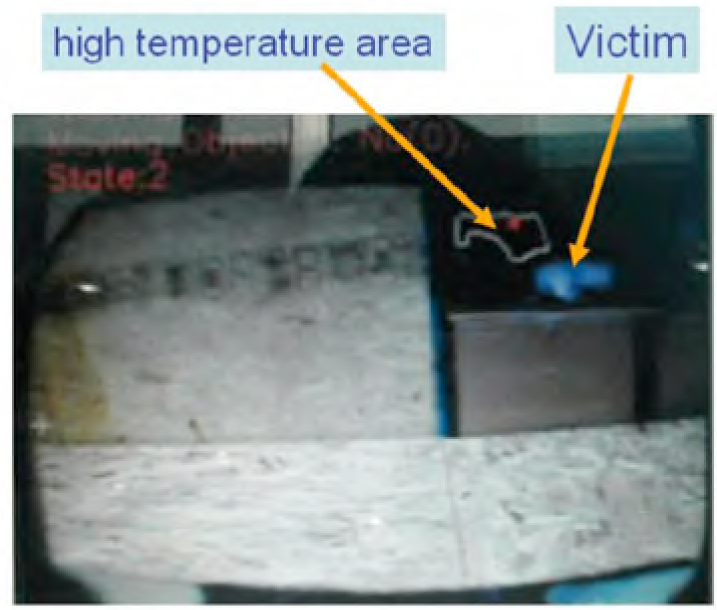


Fig. 12 The image displayed (overlay thermal camera image to normal CCD camera image)

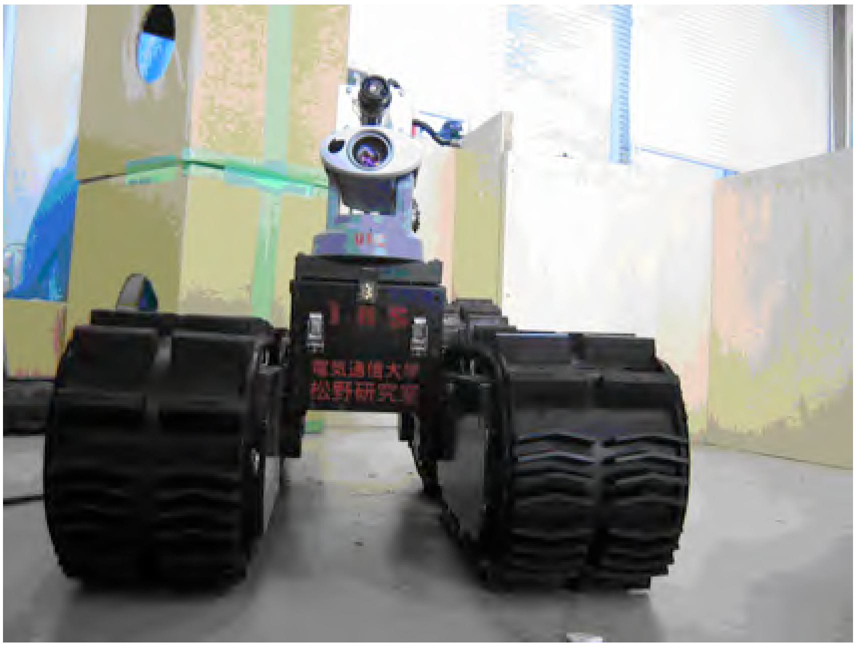
8. Robot Locomotion

KOHGA3: tracked with four crawler arm (Fig. 4)
HIEI: tracked with two flipper (Fig. 5)

9. Other Mechanisms

In robocup2006, the body of KOHGA2 was low and the bottom of KOHGA2 hit obstacles. So we changed the connection between body and arms for bottom-up. This improvement made the robot more mobility.

In addition, we will develop camera arm for finding victim who is in a high place in order to get the high score at this convention by this arm.



Fig, 13 bottom-up the KOHGA2 body

10. Team Training for Operation (Human Factors)

We have employed a commonly game pad as our control interface device, since most people are familiar with such devise. We configure the input commands for the robots as simple as possible so that the operator only needs to input few commands to control the robots. One of the difficulties of remote operation is that it is hard to control a robot in remote site only from the information provided by the cameras, as it does not provide enough details for us and make it difficult to recognize the surroundings of the robot. Our remote control method which uses a wide angle fac-ing-down fish-eye camera and virtually generate bird's eye view images will overcome this problem and also allows the operator to control the robots with ease even without long training time. In addition, we simulate the field of Robocup Rescue competition in our experimental laboratory and train ourselves for the competition (Fig.14).

Fig.14 Our training arena

11. Possibility for Practical Application to Real Disaster Site

For the practical use of our robots we need to improve the ability to control them within tough environments like water, dust, vibration, shock resistance and so on. Our wireless communication system has some weakness in not structured areas. Ad-hoc network system in wireless communication will overcome this problem.

However our systems is very useful for real disaster site without improvements men above. In 2006, we went RREE (Fig. 15). In this exercise, our system presented good mobility and controllability.

Also in Japan, our system was used by Japanese fire fighters in their training at the underground city (Fig. 16), and our university (Fig.17) in their training.

Fig.15 KOHGA2 in RREE 2006

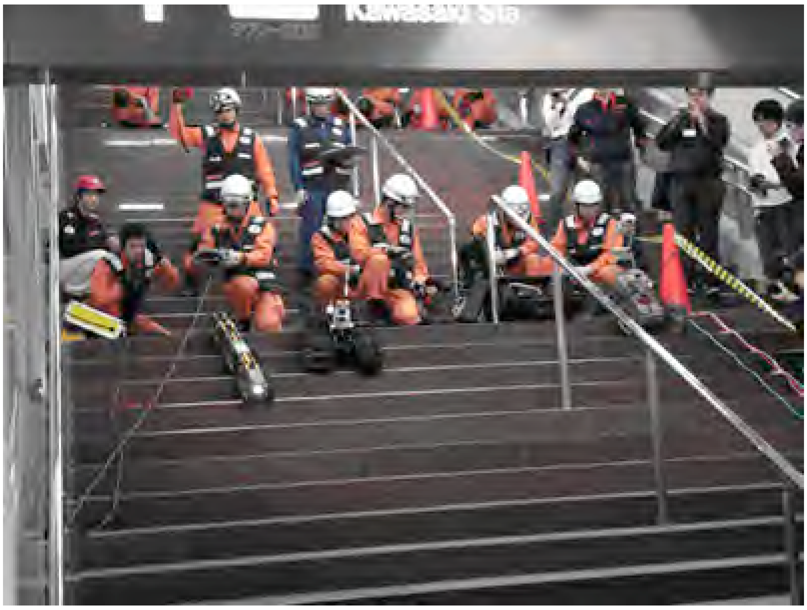


Fig. 16 KOHGA2(center robot) used by Japanese fire fighter in underground city

Fig. 17 Our robots used by Japanese fire fighters in our university

12. System Cost

(1)KOHGA3

Name	Part	Price in JPY	Number	Total price in JPY
Robot Base		6,000,000	1	6,000,000
Laser Range Finder	URG-04LX	150,000	1	150,000
3D-motion sensor	Inertial Cube3	300,000	1	300,000
Web camera	Axis 213	160,000	1	160,000
CCD Camera	KPC-S700CB	33,400	2	66,800
Fisheye lens	Minilens-fisheye	6,890	2	13,780
Micro Controller	TitechSH2	15,000	6	90,000
Motor driver	DC Servo amplifier	7,500	8	60,000
Thermal sensor	RAYMID-10-LT	60,000	1	60,000
CO2 sensor	TGS4161-A03	6,000	1	6,000
Sum Total				6,906,580

(2)HIEI

Name	Part	Price in JPY	Number	Total price in JPY
Robot Base		3,000,000	1	3,000,000
Laser Range Finder	URG-04LX	150,000	2	300,000
3D-motion sensor	Inertial Cube3	300,000	1	300,000
Motor driver	DC Servo amplifier	1,500	6	9,000
Micro Controller	TitechSH2	15,000	3	45,000
Web camera	Axis 213	160,000	1	160,000
CMOS camera	NM30	130,000	1	130,000
CCD Camera	KPC-S700CB	33,400	1	33,400
Thermal camera	THERMAL-EYE™ 3600AS	1,000,000	1	1,000,000
Note PC	ThinkPad X32	180,000	1	180,000
Sum Total				5,157,400

References

[1] Naoji SHIROMA, Georges KAGOTANI, Maki SUGIMOTO, Masahiko INAMI and Fumitoshi MATSUNO,"A Novel Teleoperation Method for a Mobile Robot Using Real Image Data Records",Proc. 2004 IEEE International. Conference on Robotics and Biomimetics (ROBIO2004), Shenyang, China, August, 2004.
[2] Naoji Shiroma, Noritaka Sato, Yu-huan Chiu and Fumitoshi Matsuno, "Study on Effective Camera Images for Mobile Robot Teleoperation", Proc. 13th IEEE International Workshop on Robot and Human Interactive Communication, 1C4, Kurashiki, Sep/2004
[3] Naoji Shiroma, Yu-huan Chiu, Noritaka Sato and Fumitoshi Matsuno, "Cooperative task excecution of search and rescue mission by a multi-robot team", Advanced Robotics, Vol.19, No.13, pp.311-329, 2005