Robocup Rescue 2018 Team Description Paper NITRo

Makoto Kitani ,Tomoki Yokotani,Keiya Hoshino, Kyosuke Ushimaru, Mifu Totani and Noritaka Sato

Info

Team Name:	NITRo
Team Institution:	Nagoya Institute of Technology
Team Leader:	Makoto Kitani
Team URL:	http://hi.web.nitech.ac.jp/

RoboCup Rescue 2018 TDP collection:
http://wiki.robocup.org/Robot_League

***Abstract*—Last year, we developed a leg-wheel type robot combining legs and wheels. Although the robot is very small (Smallest in Robocup 2017), it can overcome high obstacles by using its leg-wheel mechanisms. However, it was difficult to go through the stairs and complex terrain. Therefore, we will develop a new crawler type robot this year. It is a robot with four flippers and one manipulator.**

***Index Terms*—RoboCup Rescue, Team Description Paper, Crawler robot.**

I. Introduction

OUR team, rescue robot team NITRo, consists of students of Nagoya Institute of Technology, Japan. Our adviser, Dr. Sato, was a member of a rescue robot team SHINOBI of the University of Electro-Communications and Kyoto University, when he was a student. He had participated RoboCup Rescue World Championship from 2003 to 2009. He won Best-in-Class Mobility Award at 2005 and 2006. Moreover, he got 1st place in Japan Open 2004 and 2009, and Best-in-Class Autonomy Award at Thailand Rescue Robot Championship 2010. Team NITRo has participated in the RoboCup Japan Open since 2012. Our tele-operated tracked robot as shown in Figure, called ”NITRo-CRAWLER”, got 2nd place in RoboCup Japan Open 2014. Our autonomous robot, called ”ACCESS+”, got 2nd place in the Best-in-Class Autonomy in RoboCup Japan Open 2015. We got 4th place in the Best-in-Class Mobility in RoboCup Japan Open 2016. And we participated in Robocup World Championship 2017 with legged and wheel robot ”GOLEG”(Fig. 2).

Currently, we are developing a new tele-operated robot, called ”Hitro”. Hitro is a small crawler robot having a manipulator as shown in Fig. 1. A camera, a thermal sensor, and a speaker are attached to the manipulator to gather information. In order to inform the operator where the robot is in the arena and to get points in the Exploration tasks, Hitro has a laser scanner and creates a two-dimensional map using the SLAM (Simultaneous Localization and Mapping) technique.

Makoto Kitani ,Tomoki Yokotani,Keiya Hoshino, Kyosuke Ushimaru, Mifu Totani and Noritaka Sato are with Nagoya Institute of Technology.

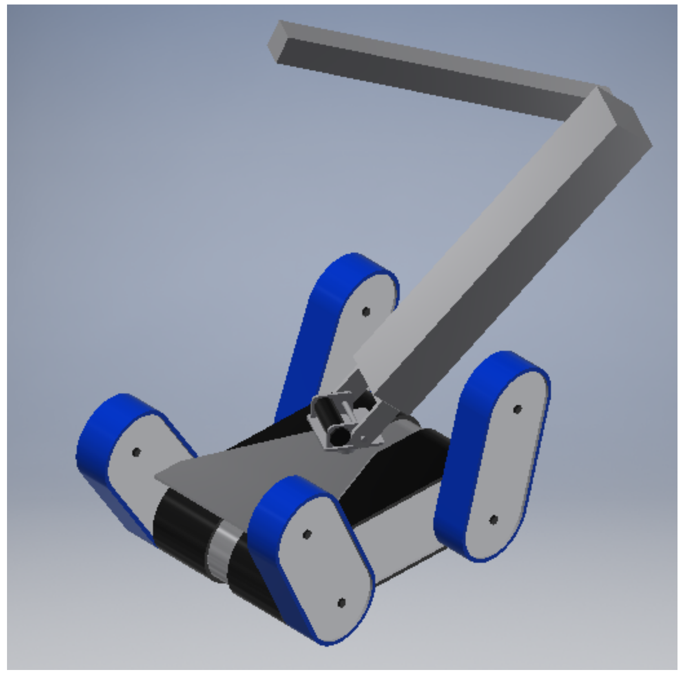

Fig. 1. Crawler robot Hitro (CG model)

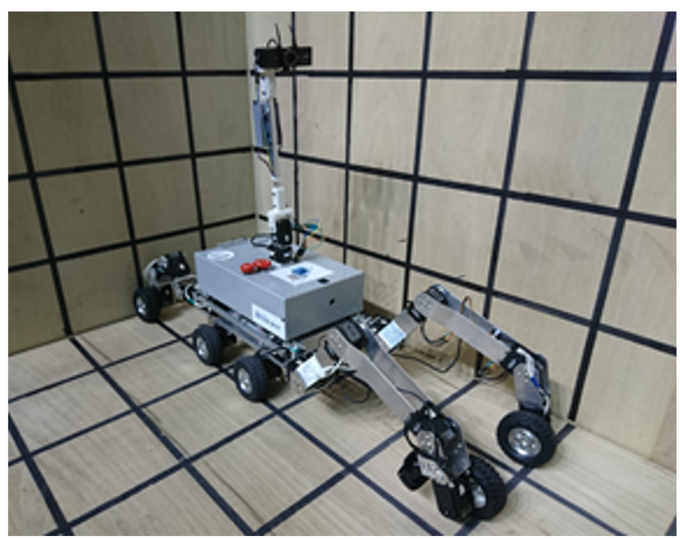

Fig. 2. Legged and wheel robot GOLEG

A. Hardware

1) Our Previous work: Our team has developed a tracked robot ”NITRo-CRAWLER” since 2014. It has two main crawlers on the both sides of the body and four sub crawlers for running on the rough terrain. By using these crawlers, the robot can run on any kinds of terrains such as stairs and step fields. Some teams have developed this type robot. One of the standard configurations of rescue robots is this type of the crawler robot in these days.Also, our team developed a tracked robot ”GOLEG” inRoboCup 2017 as shown in Fig. 2.

2) Manipulation System: Robocup rescue requires improvements of the manipulator, which is used in RoboCup 2017 in order to achieve tasks in DEX. For Robocup 2018, following three improvements will be done. First one related to a gripper part. In the previous manipulator (Fig. 3), Dynamixel AX-18 was used for the end effector. To increase the torque for rotating the valves and levers, Dynamixel RX-28 or the gripper from Sake Robotics, Inc. shown in Fig. 4 will be used. Also, in order to achieve the task DEX, the degree of freedom of the manipulator will be increased.

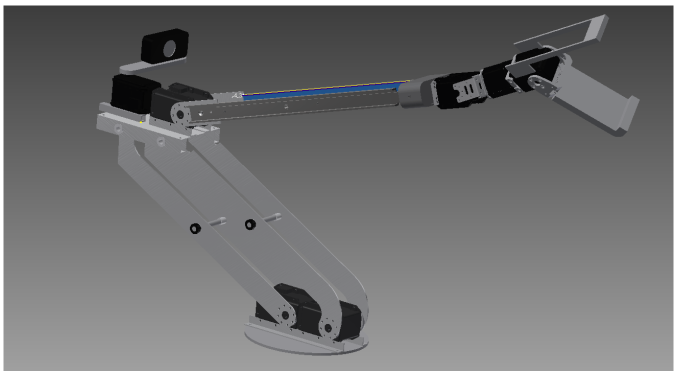

Fig. 3. Manipulator

Fig. 4. Gripper

The second one is introducing a linear motion mechanism to the second link of the manipulator. In order to be able to rotate valves in a higher position in DEX, a linear motion mechanism will be installed to second link as shown in Fig. 5. The structure of the second link is similar to an hook-and-ladder truck.

Also, since it is necessary to keep the configuration arm while reading the value of the meter, a camera is installed near the elbow joint of the manipulator so that it can be seen from a bird’s-eye viewpoint for the end effector. A spring mechanism

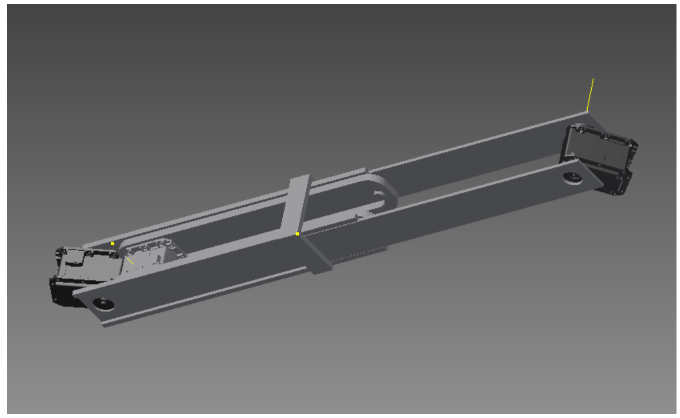

Fig. 5. The linear motion mechanism

will compensates the gravity by lifting the weight of the manipulator. The third one is the root rotation mechanism of the manipulator. The manipulator is mounted on a circular disk and A Dynamixel MX-106 is used to rotate the disk to rotate the manipulator horizontally. The Dynamixel is installed at the center of the turntable disk and casters is installed to the back of the disk at three points with 120 degree intervals to withstand the weight of the manipulator.

B. Software

All relevant software packages used by our team are listed in Table IV, given in Appendix C.

C. Communication

The communication method in our team is both of wireless and wired LAN.

D. Human-Robot Interface

It may be difficult to operate a manipulator. In our previous study, a new user interface, called “Virtual Marionette System ”, is proposed. By using this user interface, the operator can grasp the each tip of an arm in a virtual space and change the posture of the virtual robot. After that, joints of the real robot are moved so that the posture of the real robot is similar to the virtual robot by using inverse kinematics. The system configuration and the overview of the user interface are shown in Fig. 6 and Fig. 7, respectively.

E. Mapping

We have used and improved Hector SLAM for the mapping. The map by SLAM is indicated in Fig. 8. This map is generated in the final game of RoboCup Japan Open 2015. The red marks on the map indicate the position of victims. The tracks that robot passed through is also marked on the map.

F. Sensing

1) QR code reader: When a QR code appears on the image form the camera mounted on the manipulator, it is read automatically and information of the QR code is displayed on the PC monitor as shown in Fig. 9.

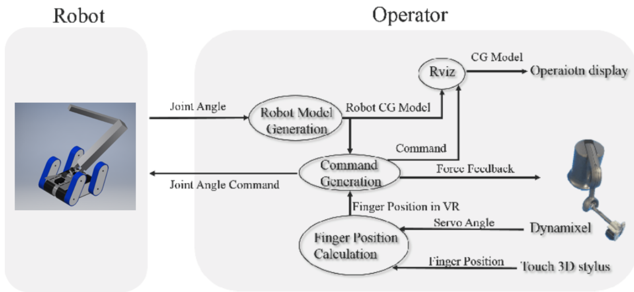

Fig. 6. System configuration of “ Virtual Marionette System ”

Fig. 7. Overview of “ Virtual Marionette System ”

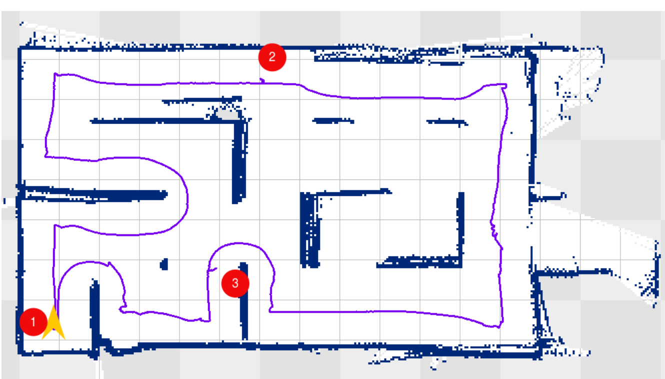

Fig. 8. Map generated in RoboCup Japan Open 2015

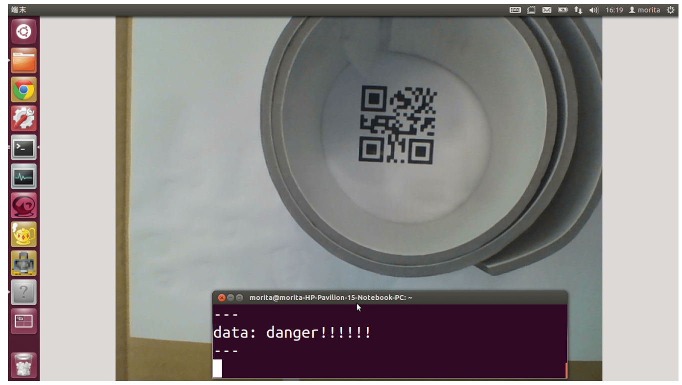

Fig. 9. QR code reader

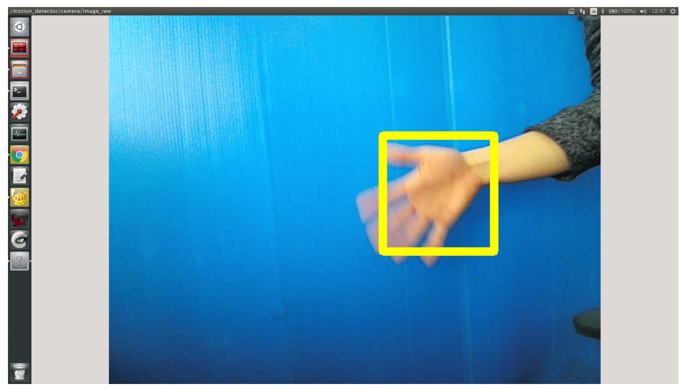

Fig. 10. Motion detection

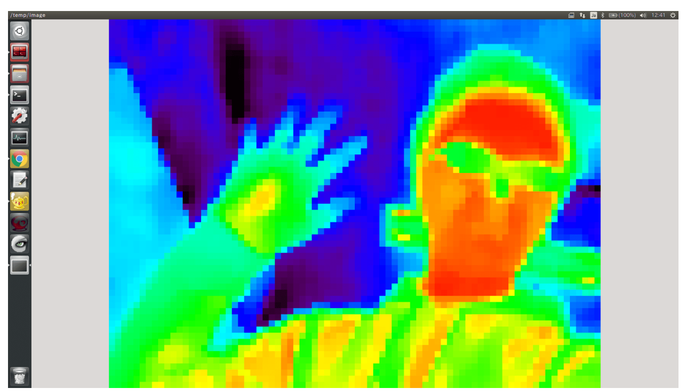

Fig. 11. Thermal sensor

2) *Motion detection:* Fig. 10 is an image when the robot detects the motion of a victim. The motion is detected from a camera mounted on the manipulator.

3) *Thermal sensor:* Fig. 11 shows thermal sensor vision. It is always displayed on the PC monitor with the camera image.

II. Application

A. Set-up and Break-Down

All the devices, which are necessary for the tele-operation, are stored in a Pelican case. The connection among the devices in the case is completed. Therefore, when the operator arrives at the operator station, he only connects one cable from the pelican case to the power supply, releases an emergency stop switch, and devices turn on. We use a wheeled dolly when carrying the robot. Therefore, our set-up and break-down methods are very simple and quick.

B. Mission Strategy

Our team would like to participate in the competition with a small robot. Therefore, the robot can pass through a narrow space. We will mainly score at MAN by taking advantage of its small size. Our new challenges are to score points at DEX tasks with a new-made manipulator. In general, almost other teams don't challenge EXP tasks. Therefore, we will challenge EXP tasks in order to get high points.

C. Experiments

Our team will participate in RoboCup Japan Open 2018 Rescue Robot League with a prototype of a crawler robot. We will get lessons learned as follow.

- It is difficult to design the algorithm about a new operation method.
- The intuitive human intervention method is necessary to control a manipulator.

Based on these lessons learned, we are developing the new crawler robot and improving the operation system.

D. Application in the Field

Our robot is a crawler-type robot that has a manipulator. In general, this robot is controlled with a gamepad. However, it is difficult to control a manipulator that has many degrees of freedom with a gamepad. A operator can control a manipulator easily with our new operation method. This method can be adapted to a construction machine.

III. Conclusion

Our team will participate in RoboCup World Championship 2018 with a crawler robot. In Robocup World Championship 2018, we will use a new system, which is bird's-eye system with a . Therefore, we are developing a high-performance crawler robot for Japan Open 2017 and World Championship 2017.

Appendix A
Team members and Their Contributions

- Makoto Kitani — Mechanical design
- Tomoki Yokotani — SLAM algorithm
- Keiya Hoshino — Manipulator
- Kyosuke Ushimaru — Programing
- Mifu Totani — Developing electronic circuit
- Noritaka Sato — Programing

Appendix B
CAD Drawing

The drawing of the robot is given in Fig. 12.

Appendix C
Lists

A. Systems List

B. Hardware Components List

C. Software List

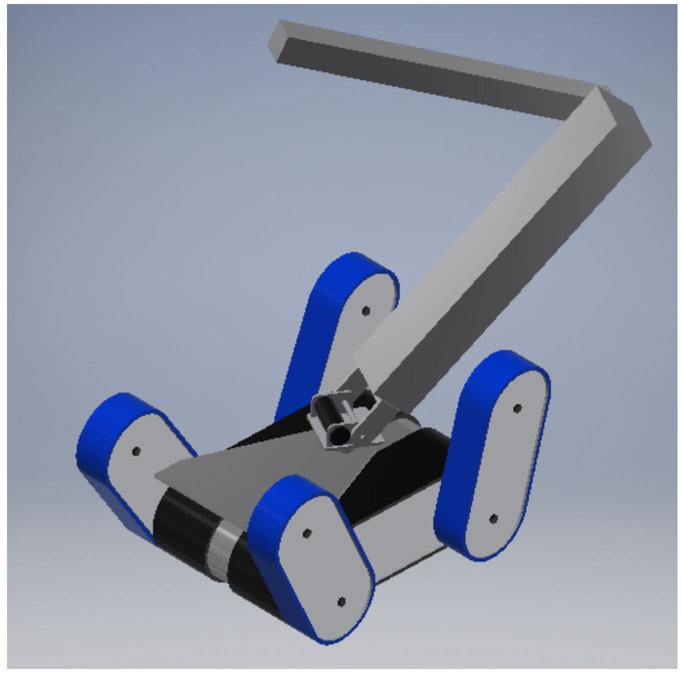

Fig. 12. CAD Drawing of Hitro

TABLE I
MANIPULATION SYSTEM

Attribute	Value
Name	Hitro
Locomotion	trucked
System Weight	30kg to 40kg
Weight including transportation case	35 kg to 45 kg
Transportation size	0.6 x 0.7 x 0.6 m
Typical operation size	0.5 x 0.8 x 0.5 m
Unpack and assembly time	5 min
Startup time (off to full operation)	5 min
Power consumption (idle/ typical/ max)	20 / 50 / 100 W
Battery endurance (idle/ normal/ heavy load)	120 / 60 / 30 min
Maximum speed (flat/ outdoor/ rubble pile)	2.0 / 2.0 / 2.0 m/s
Payload (typical, maximum)	2.0 / 5.0 kg
Arm: maximum operation height	60 cm
Arm: payload at full extend	1.0kg
Support: set of bat. chargers total weight	0.8kg
Support: set of bat. chargers power	60W (100-240V AC)
Support: Charge time batteries (80%/ 100%)	90 / 120 min
Support: Additional set of batteries weight	1.4kg
Cost	30,000 USD

TABLE II
OPERATOR STATION

Attribute	Value
Name	Virtual Marionette
System Weight	8kg
Weight including transportation case	20kg
Transportation size	0.8 x 0.5 x 0.3 m
Typical operation size	0.8 x 0.5 x 0.3 m
Unpack and assembly time	5 min
Startup time (off to full operation)	2 min
Power consumption (idle/ typical/ max)	100 / 200 / 300 W
Battery endurance (idle/ normal/ heavy load)	4 / 3 / 2 h
Cost	3000 USD

TABLE III
HARDWARE COMPONENTS LIST

Part	Brand & Model	Unit Price	Num.
Drive motors	Maxon RE35		6
Drive motors	Robotis Dynamixel RX-28	USD 160	2
Drive motors	Robotis Dynamixel MX-64	USD 350	4
Drive motors	Robotis Dynamixel MX-106	USD 570	4
Battery Management	Self-made	USD 10	1
Motor batteries	HYPERION VX G3 LiPo PowerPack	USD 30	5
Robot PC batteries	ANKER 79AN7917	USD 22	2
Micro controller	Arduino	USD 15	1
Computing Unit	Intel BOXNUC5I5RYH	USD 300	1
WiFi Adapter	none or Elecom WDC-433DU2HBK		
IMU	MPU6050		
Cameras	BUFFALO BSW20KM11	USD 60	2
PTZ Camera	none		
Infrared Camera	none		
LRF	HOKUYO URG-04LX-UG01	USD 870	1
Thermo camera	INFINITEGRA OWLIFT	USD 500	1
CO_2 Sensor	DFRobot SKU:SEN0159	USD 400	1
Microphone	BUFFELO BSHSM03BK	USD 3	1
Battery Chargers	HYPERION HP-EOS0606I-AD-C	USD 180	1
6-axis Robot Arm	Self-made	USD 1500	1
Rugged Operator Laptop	DELL PRECISION M6800	USD 1700	1

TABLE IV
SOFTWARE LIST

Name	Version	License	Usage
Ubuntu	14.04	open	
ROS	Indigo	BSD	
OpenCV	2.4.8	BSD	Victim detection
OpenCV	2.4.8	BSD	Hazmat detection
Hector SLAM	0.3.4	BSD	2D SLAM