RoboCup Rescue 2022 Team Description Paper Nexis-R

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Info

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RoboCup Rescue TDP collection
2019+: https://tdp.robocup.org/
Pre 2019: https://robocup-rescue.github.io/team description papers/

***Abstract*—The robot "R-5" developed by us won the RoboCup Japan Open as 3 rd place 2015 and has achieved the result of winning in 2016. In 2017 RoboCup Asia-Pacific ,R-5 has achieved the result of 2nd place.In 2018 WRS trial(Standard Disaster Robotics Challenge), R-5 won the championship. The activity of Nexis - R is the 13th year, and the idea learned from the robot which we have produced up to now is condensed in R-5. Currently we have developed a new arm for R-5 and realized lifting of heavy items of 10 kg.**

***Index Terms*—RoboCup Rescue, Team Description Paper, Telerobot, Disaster Response Robot**

I. Introduction

THE was originated in the establishment of our Nexis-R (former Nutech-R) is the Chuetsu Earthquake that occurred on October 23, 2004.

Nexis-R is a joint organization of Nagaoka University of Technology and local metal manufactures. Our mission is to contribute to Nagaoka area promotion who experienced the earthquake through development of rescue robot. Nexis-R has developed many robots so far and has participated in Robocup Rescue Robot League (RRRL). In 2008 the activity was appreciated and received the Nagaoka City Mayer Award.

In Nexis-R, students design the robot, and participating companies support students by design advice and difficult processing. Our lastest robot "R-5" won the WRS trial 2018 Japan open.

II. System Description

Figure 1 shows an overview of the "R-5". Charac- teristics of R5 are shown below.

A. Hardware

1) The large main crawler and four independent sub-crawlers: In order to do the exploration after the earthquake occurrence, it is necessary to have a capability to move on

Fig. 1. Nexis-R R-5

rubble of a complicated shape. Also, in order to prevent secondary disasters such as collapse of rubble, there is also a need to move softly without impinging on unstable rubble. Our robot, "R-5" made these possible by having The large main crawler and four independent sub-crawlers.

The large main crawler prevents the robot from becoming immovable when it gets on rubbles. The rubber belt used for the main crawler has two types of protrusions, large and small, with the large protrusions on the outside of the robot, and the small protrusions on the inside. The protrusion improves mobility on rubble. In designing large protrusions on the outside, the installation surface at the time of plane movement is made small, so that the load at the time of turning is reduced. This design is based on the experience of Nexis-R.

The four sub-crawlers can be moved independently. By transforming the sub-crawler into an optimum shape matching the terrain, you can grip the road surface firmly and move less impact on rubble.

Based on the above characteristics, "R-5" can stably travel the SYMMETRIC STEPFIELDS[1].

2) Self lock with worm gear: Since the worm gear is incorporated in the crawler drive, the flipper is fixed even in the non-energized state. This mechanism prevents sliding down by slope and steps.

3) Manipulator arm: The Manipulator arm of "R-5" has the following features.

- The Hand of shape following:
  The tip of the arm of "R-5" is a multi - jointed hand with three fingers(fig.2). Fingers are opened and closed by one actuator, and grasp the object(fig.3). Then, the finger deforms following the shape of the object in a

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passive way and can grasp even objects of complicated shape. Even if the robot rolls over, it is possible to return using the arm as shown in the fig.4.

Fig. 2. The Hand following shape

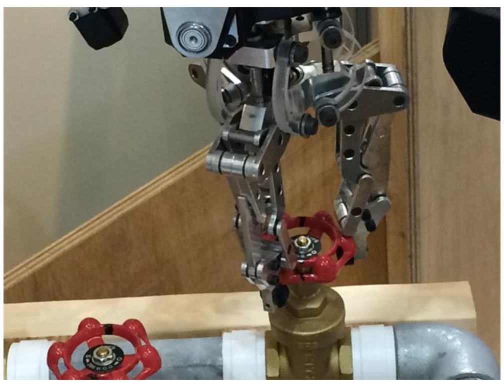

Fig. 3. Grasping of valve

Fig. 4. Returning from overturning

- Maximum length of 1.1 m with 6 degrees of freedom: As shown in the fig.5, this arm has a total of 6 degrees of freedom of one hand rotation, 4 joint rotation, 1 linear motion, for work such as opening and closing valves and doors. The arm is up to 1.1 m long, and when combined with a sub-crawler it can reach almost the same height as a human shoulder.

- Two cameras: The arm has two cameras, one at the position close to the hand and the other at the position corresponding to the elbow of the arm. The role of the first camera is to see the object. The role of the second camera is to see the positional relationship between the hand and the object, which is important in working with the hand.

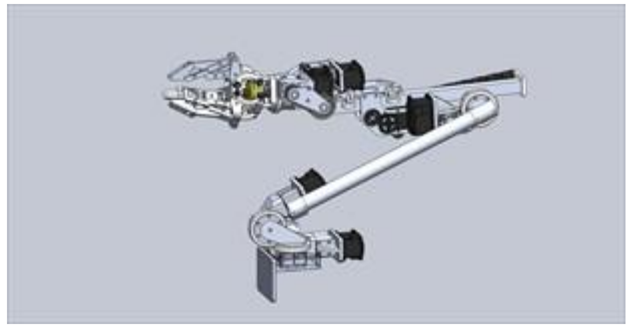

Fig. 5. Overview of the arm

B. *Software*

The basic control system diagram of “R-5” is shown in the fig.6. If you just want to run the robot, you can use only one operation PC, but you need PC of Ubuntu OS when mapping.

1) 2D mapping: We are developing 2D mapping. In the rescue operation, the map including the position of the requisite rescuer becomes important information. The mapping system consists of ”Hector SLAM[2]” and LRF. With this system we successfully mapped laboratory and hallway as shown in Fig7.

C. *Communication*

We only use one robot. Information on the radio to be used is shown below.

1) Our wireless LAN router supports IEEE 802.11 a.
2) The channel supports 36, 40, 44, 48, 52, 56, 60 and 64.

D. *Human-Robot Interface*

1) SYMMETRIC STEPFIELDS[1]: We used our own SYMMETRIC STEPFIELDS(fig.8) for daily robot mobility test and operator training.

2) User interface: As shown in Fig.9, the posture of the robot and the angle of the sub-crawler are shown by model using IMU and encoders.This is information that can not be obtained by the camera alone, and it is important information for the operator.

III. Application

A. *Set-up and Break-Down*

1) Set-up(5min):

- Carry robot and operation system
- Turn on the PC and robot
- Activate the crawler operation program
- Start the arm and camera program
- completion

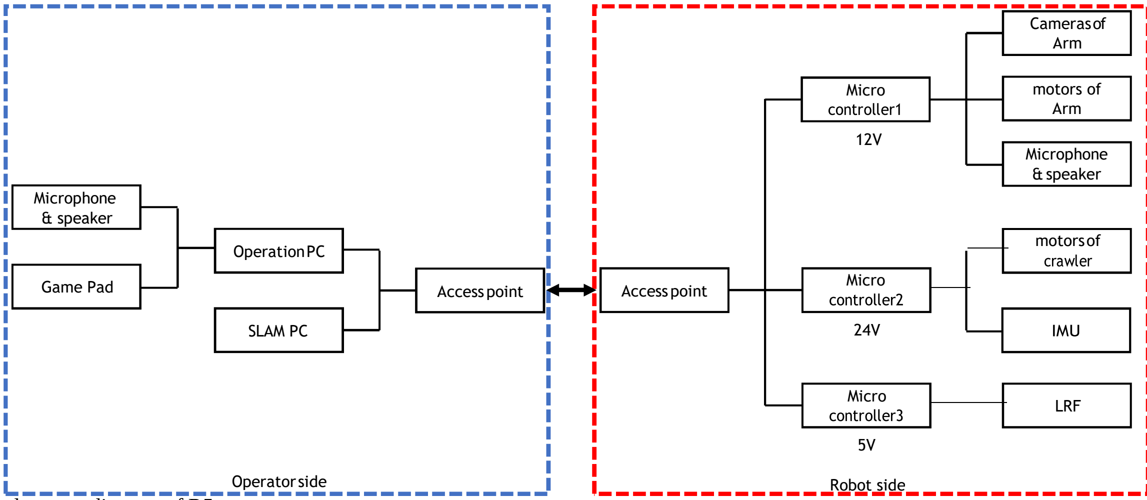

Fig. 6. Control system diagram of R5

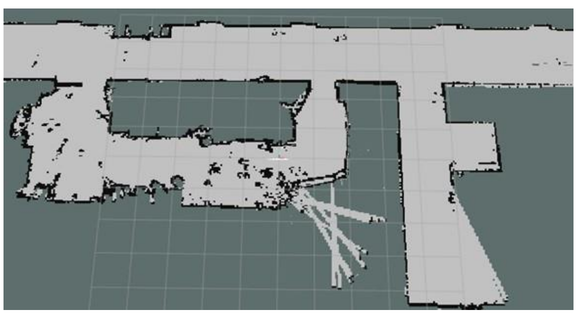
Fig. 7. 2D mapping


Fig. 8. SYMMETRIC STEPFIELDS

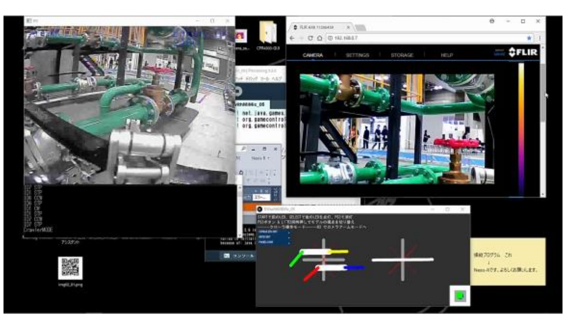
Fig. 9. User interface of R-5

2) Break-Down(3min):

- Shut down the robot
- Shut down the program
- Carry robot and operation system
- completion

B. Mission Strategy

We would like to challenge competition by making good use of "R-5" excellent mobility performance and 10kg payload arm. Since the arm has just been completed this year, we will test it in many fields before RRRL-WC and we would like to make it a reference for future development.

C. Experiments

We made our own SYMMETRIC STEPFIELDS proposed by NIST and carried out robot mobility testing. In the future, we plan to utilize STM related to arm operation.

D. Application in the Field

Although "R-5" is not immature in waterproofing function, we consider that physical intervention in the disaster area is possible because of its high level as a system performance.

Also, we consider that it is possible to transport relief supplies using the hand arm.

IV. CONCLUSION

We have developed a robot "R-5" with high mobility performance and arm performance. We will evaluate these performances with RRRL and use it as a reference for future development.

APPENDIX A
TEAM MEMBERS AND THEIR CONTRIBUTIONS

- Hayato Kobayashi — Team Leader and Operator
- Ryoga Shimizu — ROS algorithm
- Keitaro Takeuchi — ROS algorithm
- Ryutaro Sugai — Electrical design

- Haruki Hasegawa Electrical design
- Cooperative enterprises of Nexis-R Manufacturer and adviser

APPENDIX B CAD DRAWINGS

Fig.10 shows the CAD drawing of "R-5" with arm mounted.

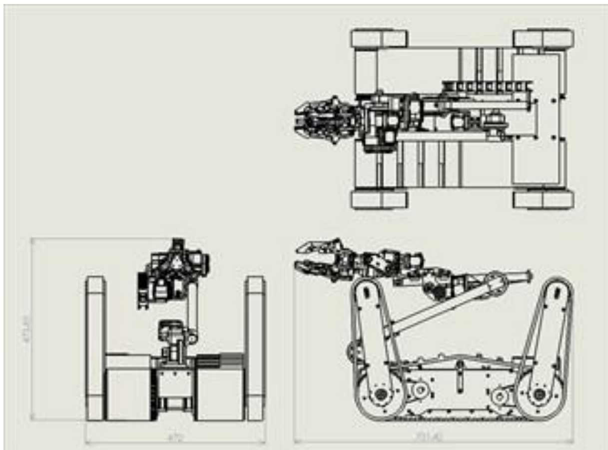

Fig. 10. CAD Drawing of R-5 with arm mounted

APPENDIX C LISTS

A. Systems List

The list of the robot system is shown in the following table.

TABLE I
SYSTEM LIST

Attribute	Value
Name	R-5
Locomotion	tracked
System Weight	35kg
Weight including transportation case	40kg
Transportation size	1.0 x 0.6 x x 0.4m
Typical operation size	0.65[max1.1] x 0.47 x 0.37m
Unpack and assembly time	10min
Startup time (off to full operation)	5min
Power consumption (idle/ typical/max)	?/216W/720W
Battery endurance (idle/normal/ heavy load)	3h/1h//0.5h
Maximum speed (flat/ outdoor/rubble pile)	0.5[m/s]/0.4[m/s]/0.3[m/s]
Payload (typical/maximum)	20kg/?
Arm: maximum operation height	1.1m
Arm: payload at full extend	10kg
Support: set of bat. chargers total weight	3kg
Support: set of bat. chargers power	200W
Support: Charge time batteries (80%/100%)	70min/90min
Support: Additional set of batteries weight	1kg
Cost	60000USD

B. Operator Station List

The list of the Operator Station is shown in the following table.

TABLE II
OPERATOR STATION LIST

Attribute	Value
Name	R5-Op
System Weight	4kg
Weight including transportation case	8kg
Transportation size	0.25 x 0.6 x 0.8m
Typical operation size	0.4 x 0.4 x 0.4m
Startup time (off to full operation)	5min
Power consumption (idle/ typical/ max)	?/50W/?
Battery endurance (idle/ normal/ heavy load)	6h/4h//3h
Cost	1500USD

C. Hardware Components List

The list of the Hardware Components is shown in the following table.

TABLE III
HARDWARE COMPONENTS LIST

Part	Brand & Model	Unit Price
Drive motors of main crawler	maxon EC-4pole 30	700CHF
Drive motors of sub crawler	maxon EC-max 30	260CHF
Drive gears of main motor	GP32HP 79:1	
Drive gears of sub motor	GP32 23:1	
Drive encoder	Encoder HEDS 5540	
Motor drivers	maxon ESCON	200CHF
DC/DC	ND	
Battery Management	lipo alarm	10USD
12V Batteries	KT3700 3S 35C	40USD
24V Batteries	KT3700 6S 35C	80USD
Micro controller1	sanritz TPIP3	1000USD
Micro controller2	mbed	ND
Micro controller3	Raspberry Pi model B+	30USD
WiFi Adapter	NEC PA-Aterm WR9500-HP	100USD
IMU	ND	ND
Cameras	raysonics RSJ-071BC	700USD
LRF	HOKUYO UTM-30LX	4000USD
Battery Chargers	HiTEC multi charger X4 AC plus	300USD
moter Robot Arm	DYNAMIXEL MX-64R	400USD

D. Software List

The list of the Software is shown in the following table.

TABLE IV
SOFTWARE LIST

Name	Version	License	Usage
Windows	7	Value	Operation
Ubuntu	14.04	Open	Mapping
ROS	Indigo	BSD	Mapping PC
Hector SLAM[2]	-	BSD	Mapping

ACKNOWLEDGMENT

The authors would like to thank Nagaoka University of Technology for their research.

REFERENCES

[1] National Institute of Standerds and Thechnology, ?gGuide for Evaluating Purchasin?Cand Training with Response Robots Using DHS-NIST-ASTM Interna- tional Standerd Test Method?h, [Online]. Available: https://www.nist.gov/sites/default/files/documents/el/isd/ ms/DHS NIST ASTM Robot Test Methods-2.pdf
[2] ROS wiki,"hector_slam",
[Online]. Available: http://wiki.ros.org/hector_slam

VIDEO

https://drive.google.com/file/d/1GL3Nd9LFWXL11DOvtMDMrq8YSfKRPhv4/view?usp=sharing
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