RoboCup Rescue 2017 Team Description Paper ROBIT

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Info

Team Name:	ROBIT
Team Institution:	Kwangwoon University
Team Leader:	Shin Yu Seop
Team URL:	None

RoboCup Rescue 2017 TDP collection:

http://wiki.robocup.org/Robot_League

***Abstract*—Team ROBIT has made many attempts in the mobile manipulator area and has already created two real-world explosive ordance disposal(EOD) robots and one mini rescue robot. and we have an environment where we can professionally design and process the simple and the most compact mobile manipulator. So we decided to participate in Robocup Rescue League held in nagoya with robotic technology base specialized to rescue tasks. It has been created to be minimal for the purpose of the competition and can show more advanced ability. For example, It has excellent obstacle avoidance ability using four flippers. Unlike competitive teams, It has the right hardware to break through hard terrain using powerful BLDC motors. A manipulator of 6DOF makes it possible to perform various tasks and perception work can also be performed through image processing technology.

Index Terms—RoboCup Rescue, Team Description Paper, up to 3 others.

I. Introduction

This Team Description Paper (TDP) will be an overview about how we made SKJL through our base technology of mobile manipulator .

ROBIT is one of the team of robot sport game team belonging to Kwangwoon University, and is a team that is involved in the development of mobile manipulator platform and rescue related work. We have been studying mobile robots for about 10 years and have recently made MK1 / MK2 for EOD work. Belowing Fig. 2 shows MK1 / MK2.

Through this, we redesigned SJbot to make Robocup rescue. The motor selection was the most important because it needed to be able to break through various terrain before the production. We applied the kinematic equation to calculate the required power and torque. so we selected a motor that can run smoothly. Sprocket and chain structure and built in aluminum frame are equipped with rubber to increase frictional force.

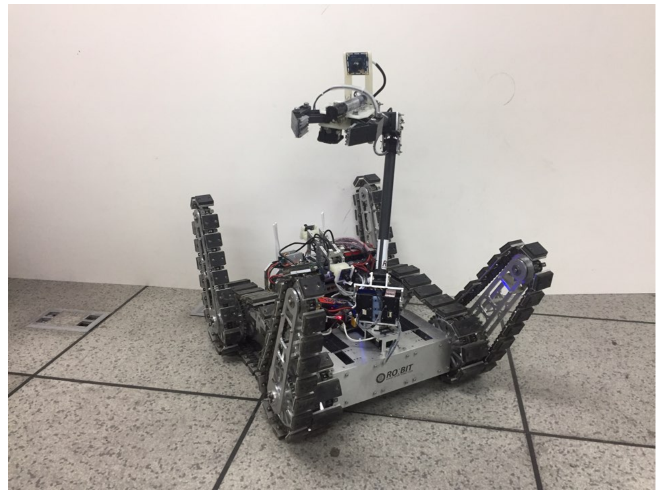

Fig. 1. Prototype of SJbot

Fig.2. Left - MK1 using mecanum wheel. Right - MK2 using track.

and in perception part, It can perform color, pattern, motion recognition, etc. through image processing technology using Open CV. We also used various sensors, which have perception capabilities such as CO2 measurement, and audio. and It can be operated with a self-made controller.

We have not built mapping technology at present. However, we will build a more developed SKJL system by installing mapping technology within a short period of time.

II. System Description

In this part, we briefly describe our skills in communication and GUI as well as hardware and software. We have been able to build better hardware than other teams through years of know-how. Of course, control technology and software are supported. The lack of mapping technology is covered by advantages. Mapping technology also be under development.

A. Hardware

SKJL is designed with a width 55cm, a length 65cm except the flippers, and a length 110cm after flipping the flippers straightly. Weighing about 40kg.f, we focused on weight saving and selected motor. Most of them, except for the arm, were made of aluminum. The 3D printer was used in areas where intensity was not really needed.

1. Dynamics Equation of SKJL

We solved the kinematic equations by setting the target speed and capability ahead of hardware design. This was a great help in choosing a motor and we were able to set the weight of the SJbot. First, let's examine the target specification.

Speed : 0.6~0.8m/s at flat. it is based on Wheel radius : 10cm and no load rpm : 100rpm.

Weight : 30~35kgf (including arm)

Capability : 45 degrees slope & stairs driving at 0.3m/s

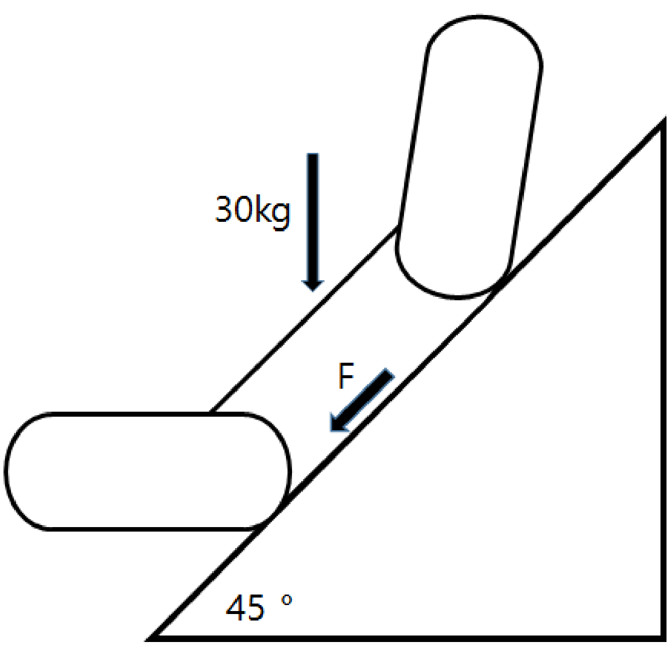

Fig. 3. Simulation in slope of 45 degrees

First of all, using the Newton's second law, we can establish the following equation.

$F = m * g * sin\theta$ = 30 * 9.81 * sin45 ° = 208 N (Force that not to be slipped)

and then , It is possible to set up an equation related to torque.

τ = Fr = 208N $*$ 0.1m(Wheel radius) = 20.8N· m

and multiplies safety factor by considering various external factors. Because there are two motors, It must be calculated the torque that each must load.

20.8 * Factor of Safety 1.5 = 31.2N ·m / 2 = **15N · m** per single motor

Finally, Acceleration section should be considered.

Acceleration section) $ma = F - Wsin\theta$

$ma = \tau/r - W\ sin\theta$

$\tau = r*m*a + W\ sin\theta*r$

(W = Weight = $m * g * sin\theta$)

In acceleration section : 1~2N · m is needed more

2. Mechanical Specification

This is the part that show SKJL's important mechanical

specification.

1) Main track Motors : N6374 BLDC motors for electric board
   Power : 3KW
   Speed : 295KV
   Shaft : 8 PI
   Weight : 850g

2) Motors for 4 flippers : IG-42GM 01 TYPE DC motor
   Power : 40W
   Speed : 400rpm
   Shaft : 8PI
   Weight : 400g

3) 6 DOF Arm : Dynamixel MX-106 for Yaw / MX-64 for others

4) Frame : Aluminum

5) Harmornic gear
   Harmonic gear no.20 (gear ratio 50: 1)for each main track motor
   Harmonic gear no.17 (gear ratio 50: 1)for each flipper.

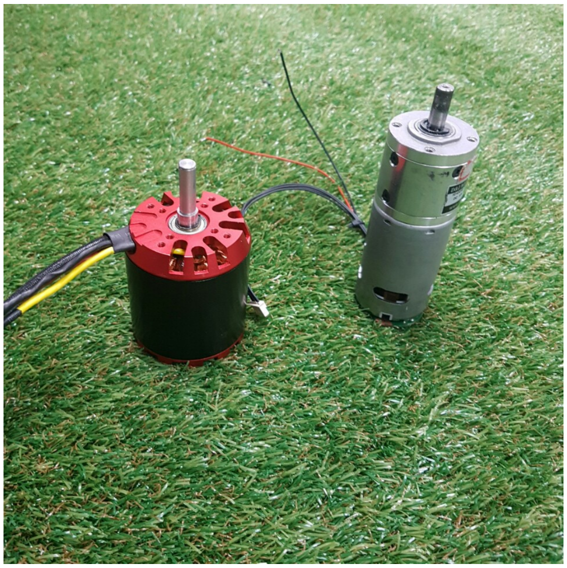

Fig. 4. Left - N6374 / Right : IG-42GM

Fig. 5. Harmonic gear

3. *Electrical Specification*

This is the part that shows our important Electrical specificatio
For the MCU and motor controller for flipper motors, we used our self-production module.

1) Computing Unit : GYGABYTE i7 3.2GHZ
2) MCU : MC56F8257VLH by Freescale
3) Joystick : self-production module using MC56F8257VLH
4) Motor Controller : VESC / self-production driver.

Fig. 6. Main Controller Module

Fig. 7. Joystick

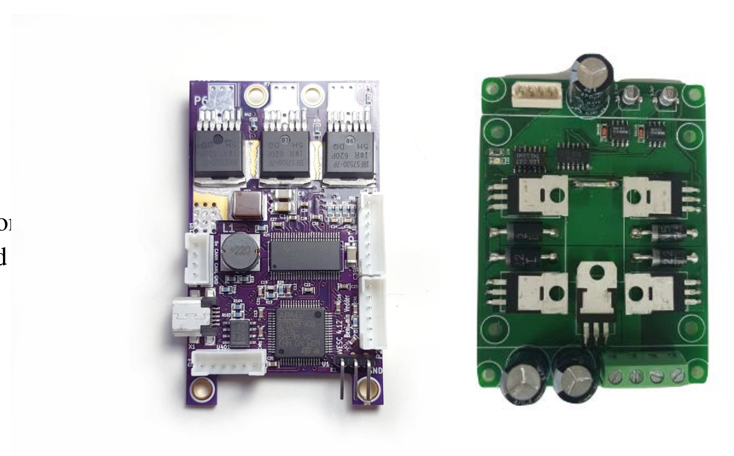

Fig. 8. Left - Benjamin Vedder's VESC, Rigth - DC motor Driver

4. Locomotion

The SJbot is designed with two main drive tracks and four flippers. First, the main drive consists of two motors, right and left. For ease of motor placement , the belt is used to transmit power from the motor to the pulley, and the transmitted shaft of the pulley drives the harmonic gear. The flippers was designed to break through the stairs and tough terrain. 4 motors are connected to each flipper, allowing independent movement and delivering sufficient power. 4 motors were equipped with a 50:1 gear ratio harmonic gear.
In the rescue tasks, the part where the wheels touch the ground is also very important. SKJL is used a track structure to climb the hard terrain and stairs. The power transmission system of the track structure is divided into a pully-belt structure and a sprocket - chain structure. We chose a chain because of a low probability of breakaway. and we designed the track by using an attachment chain & our self-made sprocket and fixing the rubber on it like Fig.11

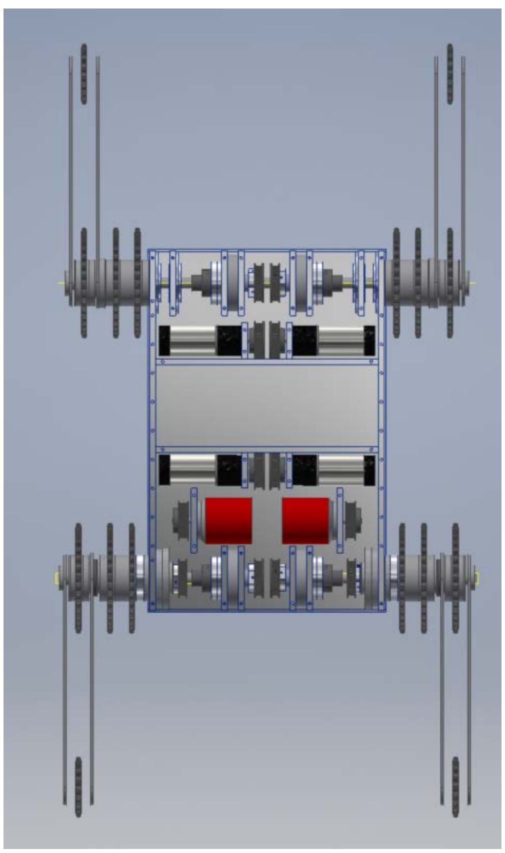

Fig. 9. Inventor 3D drawing 1

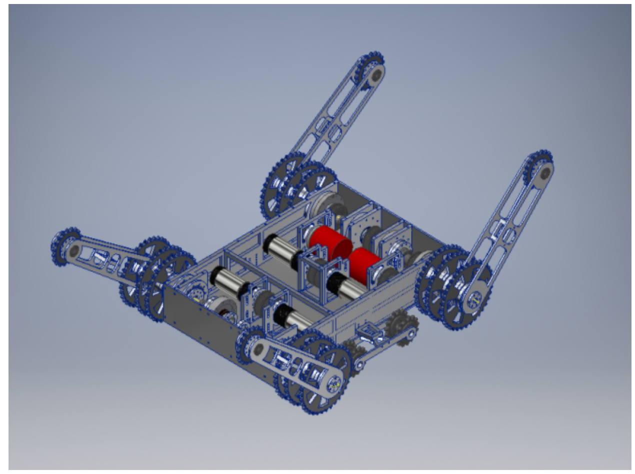

Fig. 10. Inventor 3D drawing 2

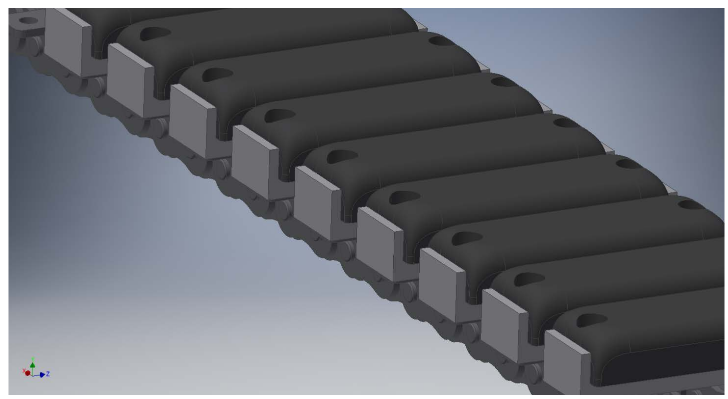

Fig. 11. Track design

5. Manipulation / Directed Perception

The arm of the SKJL can extend up to 1.5m including the mobile base height, it is designed with 6DOF for more freedom of movement. We used Dynamixel MX-106 for yaw-axis and the rest Dynamixel MX-64. The main point is that carbon pipes were designed as mainframe to reduce weight and strength.

6. Sensors & Cameras

We used the CO_2 sensor SH-300-DS for the end effector . This allows the ppm value to be sent to the operator. And a microphone inform the operator of the emergency situation.
The camera is consist of one camera for image processing tasks and four cameras for operator's control. It is possible to control the arm more delicately while checking the front and back sight.

B. Software

1. Victim Detection

Victim detection is one of the most important task of Rescue. SKJL has a function to whether a victim is alive or dead by using CO2 sensor. In addition, image processing using Open CV enables motion , pattern, and color detection. This can be used to detect human movement or warning signs.

2. Main Tools

For the BLDC control, we used the tool provided by the Benjamin vedder. With this tool, basic setting of motor controller, PID control and setting of Hall sensor can be done.

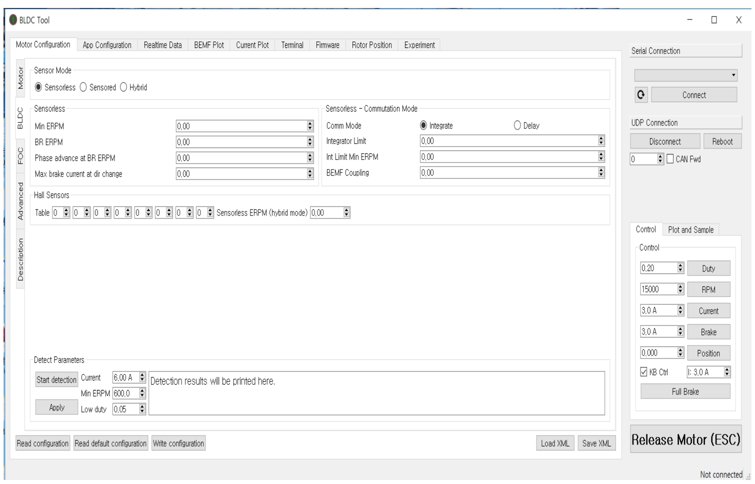

Fig. 12. BLDC tool

Basic firmware and software coded through Codewarrior and QT creator. In the mini pc, the operator side transmitter signal is sent to the motor controller via linux based QT creator. And most of the four camera for operating are transmitted through QT.

2. Arm control

Arm control recognizes its position through communication between arm joints and sends the data to the operator. And the joint position control using inverse kinematics makes the end-effector to reach the target position. This is the most important part of dexterity tasks.

C. Communication

Main communication system is wireless LAN based on IEEE 802.11a - 5GHz using ipTIME A2004R.
The operator gives commands to the robot's mini pc via LAN .
The mini pc sends the data to the main MCU via RS485 communication, and the robot is driven by this data.

D. Human-Robot Interface

The system between the operator and the robot is illustrated in Fig.13. and We have a variety of robots' visibility and have created a GUI environment that allows us to operate easily. The GUI can show the CO2 value and the speed of the robot.

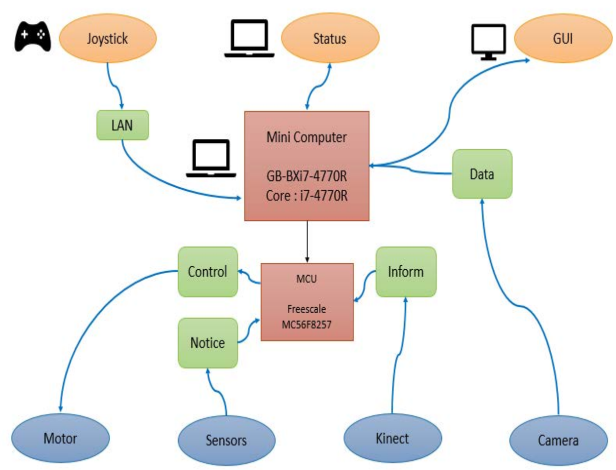

Fig. 13. System Block Diagram

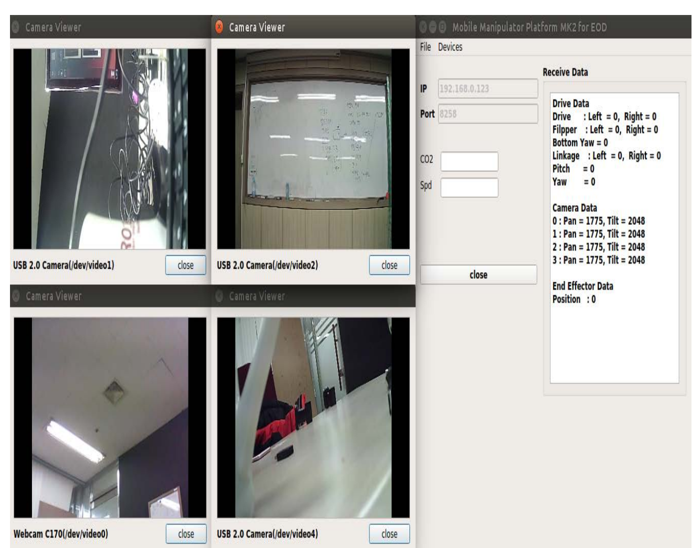

Fig. 14. Operator GUI

III. APPLICATION

A. Set-up and Break-Down

Our team has a minimal set-up environment for quick set-up in a limited time.

First, the driver environment consists of a spare monitor that will receive images taken by the robot, a notebook that can show the status of the robot, and a controller.

Communication between the robot and the controller has been improved by adopting UDP communication over the LAN line.

In the break-down situation, after disconnecting the power supply and send the 'On' signal so start the power again. In setup-up and break-down process, each takes less than 3 minutes.

B. Mission Strategy

We think it's top priority to shorten the time in Readiness test and to get the best score of 10 points.

In addition, the strategy of the hardware part was designed as a robot optimized for rough terrain by adopting a chain type driving part that compensates the shortcomings of the existing MK1 / MK2.

The software part will utilize technologies such as acceleration / deceleration, position control, etc. so that the robot can move as desired by the operator.

C. Experiments

We have the basic environment for testing mobility and end-effector Future experiments will be conducted in the most similar environment to the actual robocup rescue by participating in the 2017 korea robocup rescue open which will be held during 2 / 17-18.

After participating in Korea robocup rescue, we will discuss with team members regarding difficulties and unexpected situations during the competition and will make corrections and supplements until robocup rescue.

D. Application in the Field

We think that the most important part of the field is mobility. The reason for this is that the robot can not function as a rescue robot if it can not get to where the victim is. So our team is making robots that are optimized for mobility. The first is light weight. The weight of the robot can be increased by the torque of the same motor, and the lifetime of the robot will be extended. The second is the grounding force. We will select the chain type driving unit and will produce the best grounding force among the same class robots.

IV. CONCLUSION

It will be a good opportunity to test our skills and develop a bit more as we are participating in ROBOCUP RESCUE for the first time. Mapping technology will be introduced to improve performance.

APPENDIX A
TEAM MEMBERS AND THEIR CONTRIBUTIONS

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- Kim Jun Ho Hardware design supporter

APPENDIX B
LISTS

A. Systems List

TABLE I is MANIPULATION SYSTEM list about tele-operated robot-SKJL. It tells the overall specifications about hardware. TABLE II is about operator.

TABLE I
MANIPULATION SYSTEM

Attribute	Value
Name	SKJL
Locomotion	tracked with chain
System Weight	30kg
Weight including transportation case	40kg
Transportation size	0.6 x 0.6 x 0.5 m
Typical operation size	0.5 x 1.1 x 0.7 m
Unpack and assembly time	150 min
Startup time (off to full operation)	15 min
Power consumption (idle/ typical/ max)	60 / 200 / 800 W
Battery endurance (idle/ normal/ heavy load)	180 / 120 / 90 min 0.9 /
Maximum speed (flat/ outdoor/ rubble pile)	0.7 / - m/s
Payload (typical, maximum)	5/ 10 kg
Arm: maximum operation height	150 cm
Arm: payload at full extend	1.5kg
Support: set of bat. chargers total weight	4kg
Support: set of bat. chargers power	1,200W (100-240V AC)
Support: Charge time batteries (80%/ 100%)	90 / 120 min
Support: Additional set of batteries weight	2kg
Any other interesting attribute	?
Cost	6000 USD

TABLE II
OPERATOR STATION

Attribute	Value
Name	SKJLOperator
System Weight	3kg
Weight including transportation case	4kg
Transportation size	0.5 x 0.6 x 0.2 m
Typical operation size	0.6 x 0.8 x 0.4 m
Unpack and assembly time	3 min
Startup time (off to full operation)	3 min
Power consumption (idle/ typical/ max)	- / - / - W
Battery endurance (idle/ normal/ heavy load)	10 / 5 / - h
Any other interesting attribute	?
Cost	- USD

B. Hardware Components List

list of notable hardware components about SJbot is provided in TABLE III.

TABLE III
HARDWARE COMPONENTS LIST

Part	Brand & Model	Unit Price	Num.
Drive motors	Sensored n6374 BLDC	USD 80	2
	IG-42GM	USD 80	2
Drive gear	Harmonic gearhead	USD 400	2
Motor drivers	Vedder's VESC	USD 125	2
DC/DC	-	?	-
Battery Management	-	?	-
Batteries	Lipo 6cell	USD 250	2
Micro controller	Freescale MC56F8257	USD 8	3
Computing Unit	Mini-PC GIGABYTE	USD 600	1
WiFi Adapter	ipTIME A2004R	USD 85	1
IMU	-	?	-
Cameras	ELP USB Camera	USD 17	4
Vision Camera	Logitech	USD 85	1
Infrared Camera	-	?	-
LRF	-	?	-
CO_2 Sensor	SH-300-DS	USD 90	1
Battery Chargers		-	1
Sprocket	SP 40B	-	12
Chain	CHET 40B	-	-
6-axis Robot Arm Motors	MX-106	USD 400	2
	MX-64	USD 250	4

C. Software List

TABLE IV
SOFTWARE LIST

Name	Version	License	Usage
Linux	-	open	
OpenCV [12]	2.4.8	BSD	
Codewarrior Development Studio	10.6	BSD	
Qt Creator	2.4.8	BSD	
BLDC tool	10.3	BSD	

ACKNOWLEDGMENT

The authors would like to thank...

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