Toin Pelican

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Abstract. In this paper, we describe on our developed mobile robot with 6 crawlers which can change its form. The robot has some features. It can move both of on flat ground and on rubble efficiently by changing the form of crawlers. The robot has a multi-sensor head on the top of a 5-degrees of freedom manipulator. It will be enable to detect the information of victim because the sensor head can select various position and angle by controlling the manipulator. Furthermore, the robot has both of a wired and a wireless LAN for robust communication.

Introduction

The followings are guideline to design our system. We consider they are important to find a victim in an afflicted area efficiently.

1) Road ability on all-terrain including rubble

The robot can accomplish on all-terrain. Road ability is more important than speed to move.

2) Finding the victim

It is best way to find the victim when the robot is moving. On the other hand, we should find the victim even if we stop the robot.

3) Environmental map in an afflicted area

A victim's accurate position is necessary to rescue the victim rapidly. It is also important to show a route which is safely to move for rescue staffs. Then, we intend to make the three-dimensional map in the afflicted area.

4) Operation of the robot

An operator is under enormous pressure. He/She may be afraid of second accidents and try to find the victim speedy. Then, we make an user friendly interface. We make the interface which is easy to use by a fatigued and unskilled operator.

5) Utility

Real afflicted area is more difficult to move than the area of the contest. We are verifying that what is the robot. We verify what kind of equipment is necessary against leaks, the poisonous gas, flammable gas, the radiant heat due to the fire, and so on.

At present, we are developing 6 crawler pattern rescue robot which shows it in the figure -1.
The characteristics of this robot are as follows.
1) Form variable pattern crawler system
Crawler of this robot is composed of six parts, and it can change the form by the condition of the running way.
Front and back are raised by running of flat ground.
The robot in this posture, it doesn't do crawler of the horizontal part on the ground.
Because of this, a spin turn and a pivot turn can be done easily.
And, there is a little friction, and good running of the efficiency is possible so that a horizontal part may not do on the ground.
2)The sensor head carried on the 5 DOF manipulator
This manipulator is used so that an operation staff may get the information of the reliable victim from close range.
The strong microphone of the stereophonic vision, the wide area microphone and pointing, Phrelectric motion sensor, Themopile detector and carbon dioxide sensor are installed on the sensor head.

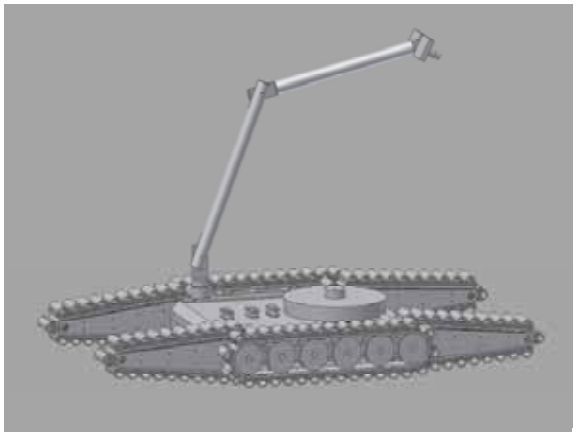


Figure -1 Rescue robot

3) Ethernet wire wind device with the automatic tension adjustment function
When it is moved in the debris, a wire makes bad for the freedom of the behavior of robot.
On the other hand, it is very difficult to secure radio communication at the large-scale underground market and the big depth underground market.
The transmission of the accurate information is difficult by the communication delay by more than one user, the noise, and so on.
It is important for the lifesaving that the high reliability transmission method is chosen.

So, we are developing the wire wind device with the automatic tension adjustment function which doesn't become a burden to the operator.
We think that it is important by the rescue activities with the synthetic system which a fault is rare.

1. Team Members and Their Contributions

We are the student who belongs to the Toin Yokohama university, the department of engineering and the mental mechanical engineering course, and an instructor.
The students are in the second grade at present.
They participates in many robot contests except for the lecture on the university, and they get actual results. It is useful to learn professionalism.

- Yasuo HAYASHIBARA Controller development
- Eiji KOYANAGI Mechanical design
- Yoshiyuki OOBA Operator & Wind the cable mechanism design
- Shuuhei YOSHIDA Operator & Manipulator design

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

When rescue activities are developed in the stricken area, and it is demanded that equipment goods are miniature, light weight, and excellent in carrying.
And, the loss of the setup time is thought to be fatal by the rescue activities.
Equipment except for the robot's own of our team is as follows.
1）Notebook PC : one unit
2）Joystick controller : one unit
3）Joy pad controller : one unit
4）Adapter for the wireless orchid : one unit
Operation staffs are tow. One of staff is operating the robot running and the other one is operating the 5DOF manipulator.

3. Communications

Last year, we joined the F180 league of RoboCup Japanese opening.
At that time, because 802.11B（2.4GHz） was being used for the communication system, it did an experience that a robot couldn't control it at all.
Because of this, the state of communication which became stable by using 802.11A（5.2GHz） could be secured at Padova Italy convention.

The system of 802.11A used for the figure -2 at Padova convention is shown.
This time, it is two methods that we make preparations.
One is the wireless orchid of 802.11A with the actual results.
The other one is Ethernet 100Mbps of the cable .
As for the cable form, reliable transmission and reception are possible though there is a problem of the handling of the wire.
Specially, when search activities in the large-scale underground market are presumed, the range that a present wireless system functions is limited to very few areas.
On the other hand, it may be buried in the debris, and the cable wound around the drum may be stuck, and collection may be difficult.
In this case, if it is the possible range of the radio communication, a drum is given up, and only rescue robot thinks that it returns, too.

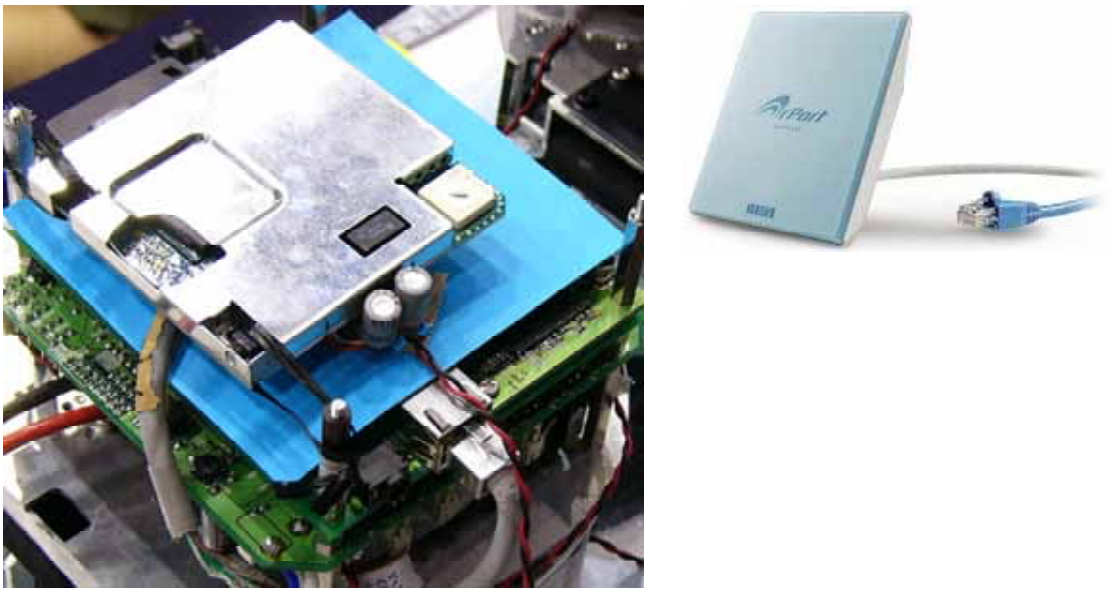


Figure -2　A mounted 802.11A system

4. Control Method and Human-Robot Interface

The basic experiment of the autonomy movement is being done to reduce the burden of the operation staff.
A self-position can be estimated by odometry when it runs through flat ground with the mobile robot which used a wheel.
On the other hand, a result to show in the figure -3 can get it by the autonomy movement of the mobile robot which used crawler.

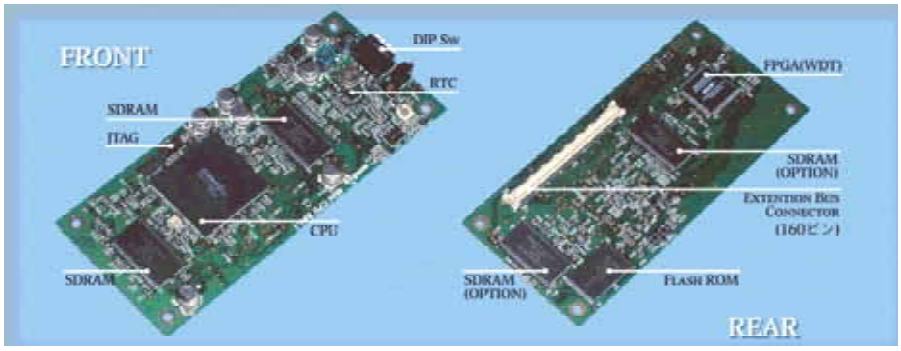
The moving distans error of the mobile robot with crawler is biger than the robot with wheel though it is the corridor of the flat inside.

It predicable that an error grows big in the debris due to the slip and so on.

At present, an autonomy movement due to the fusion of odometry and the laser distance sensor is examined.

The controller which shows it to the robot during the development shown in the figure -1 in the figure -3 is carried.

Figure -4 Autonomous mobile robot



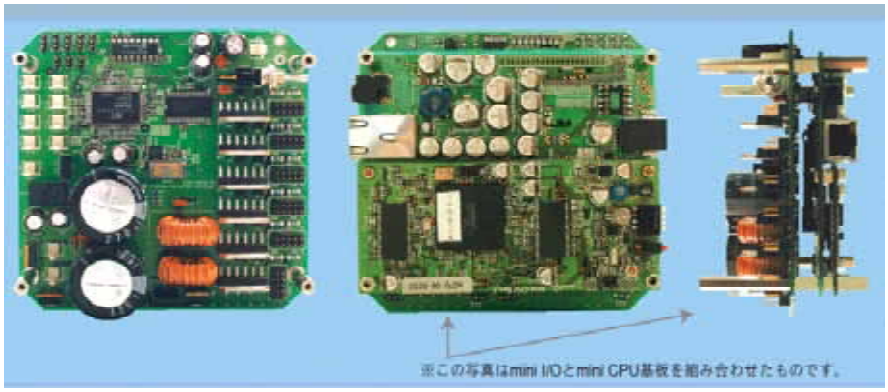


Figure -5 Controller

Table 1 Specification of the Electro Circuit

Size	120mm x 120mm
CPU	Renesas Technology SH-4 (200MHz)
ROM	Flash Memory 4MB (8MB)
RAM	SDRAM 32MB (64MB)
OS	NetBSD (UNIX Compatible)
Software	WWW Server, Mail Server/Client, PPPoE, DHCP Client/Server, VPN
LAN	100Base-T
Serial	RS232C x 1ch (Console)
CF Card Slot x 2	CF(32MB) x 1, Wireless LAN/Other x 1
2.5”HD	Connector x 1
I/O	120pin High Speed Extended 32Bit Bus (100MHz)
Motor Driver	SGS LC6203 x 6ch (Generating Pulse by FPGA)
Kick Device	Applying High Voltage Condenser (450V)
A/D Converter	MicroChips MCP3208 (8ch)
Gyro Sensor	Murata ENC-03J (Max. 300deg/sec x 3ch)
Acceleration Sensor	Analog Devices ADXL202
Video Capture	CONEXANT Bt829B (4ch)
Power Supply	DC9-20V

A robot is operated by the joystick which showed it in the figure -5, and 5 DOF sensor head is operated by the joy pad by the actual operation.

Figure -6 A joystick for the robot control and a joy pad for the manipulator control

5. Map generation/printing

At present, the technique of SLAM（Simultaneous Localization And Mapping）［1］is realized with building of the environmental map and the estimation of the self-position in the two-dimensional environment.

The sensor information which it got newly with the well-known three-dimensional environment information is compared, and correlation operation is done, and we are developing the technique to estimate a current position for the three-dimensional environment.

Building of this three-dimensional environment map and self-position estimation are realized by the next process.

1）A robot is made to run from the place where a three-dimensional environmental map is being built.

The environmental map being built is called a global map here.

2）A fixed distance makes a robot run.

3）A laser range sensor is scanned, and it gets three-dimensional distance information.

4）A local map is made from the data which it got.

5）The correlation of the global map and the local map is taken.

6）The self-position of the robot is estimated in the top of the global map.

7）Information on the local map is added to the global map based on the estimated self-position.

8）The movement of the 2）～ 7）item is repeated.

Many memories and the computer power are necessary to build a three-dimensional environment map.

There is DEM（Digital Elevation Map）［2］as a technique of the environment expression of the un-leveling of land.

On the other hand, the inside of the building which collapsed is the space closed by the wall which crumbled, the beam, and so on.

So, Sphere-DEM［3］is used from the distance information to scan a laser range sensor and which it can get directly, and it is the plan to build a three-dimensional environment map.

6. Sensors for Navigation and Localization

6.1 Sensors for Navigation

1）Rotary encoder : the movement speed of the robot

2）3 ch gyro sensor : The roll of the robot, a pace and an angular velocity on the corner of ヨー are detected.

3）2 ch angle of inclination sensor : The posture of the robot is detected.

4）The front monitoring camera : The environment of the running way is confirmed.

5）Back monitoring camera : The watch of the communication cable and the environment of the

running way in the younger person are confirmed.

6) The stereophonic vision carried on the 5 DOF manipulator : A running way from the high position and the condition of robot is confirmed.

6.2 Sensors for Localization

1) Rotary encoder : Running its personal history is acquired.

2) Laser range sensor : building of the three-dimensional environment map

At present, SICK company is being used.

But, this model is big, and there is a fault to be heavy in it, and it can't be carried on the new-model robot.

So, there is some information that a miniature laser range sensor is manufactured as an experiment from the Japanese sensor maker this April, and considers using that product.

7. Sensors for Victim Identification

We get the information of the victim by the multi-sensor head carried on 5 DOF manipulator from the various position, postures.

1) Stereophonic vision : The conditions of the victim, distance information are recognized by the sight.

2) Themopile detector : The temperature which the victim appears on is detected.

3) Phrelectric motion sensor : The temperature which the point victim appears on is detected.

In comparison with the information on Themopile detector A source of heat of the wavelength which is different from the human body is deleted.

4) The wide microphone of pointing : the sound which the victim it thought to be in the neighborhood of the robot started to signal is detected.

5) The small microphone phone of pointing : a source of occurrence is confirmed from the detected sound signal, the victim.

6) Carbon dioxide sensor : Though it will be carried, a model is being selected at present.

8. Robot Locomotion

We are developing 6 crawler mobile robot of the form variable pattern as a mechanism of the movement.

Crawler of this robot is composed of six parts, and it can change by the condition of the running way 【 the form 】.

The internal structure of the body is shown in the figure -5.

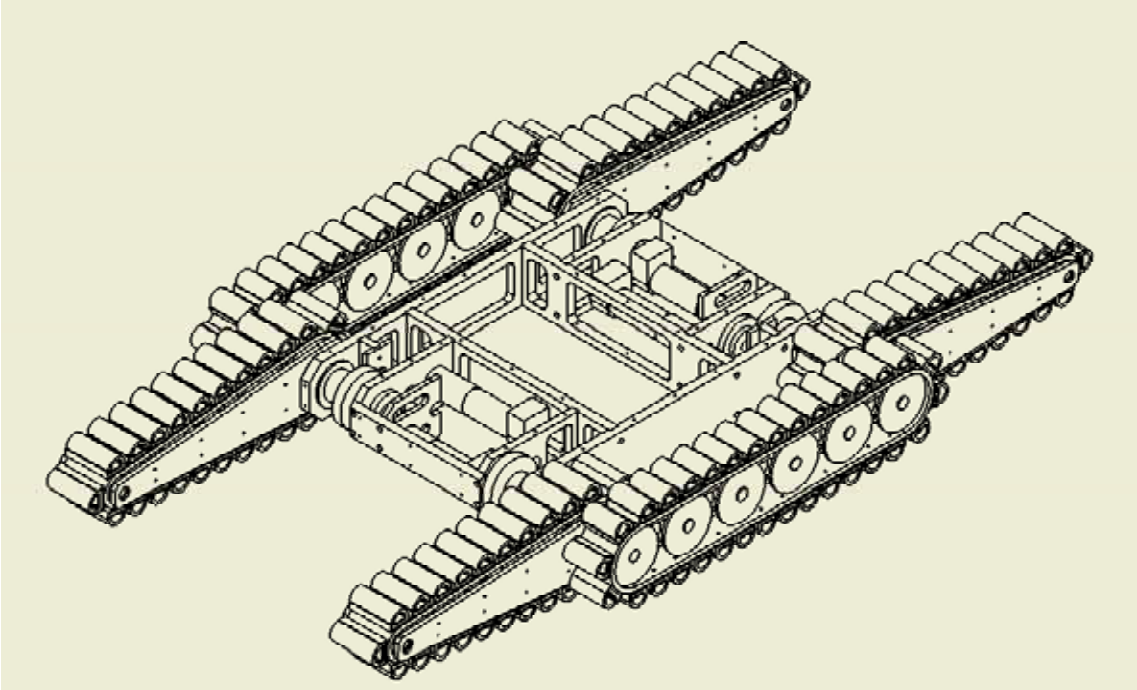


Figure -7　The internal structure of rescue robot

１）Move in flat ground （figure -8）

Front and back are raised by running of flat ground.

接 area doesn't do crawler of the horizontal part in this posture in the ground.

Because of this, a spin turn and a pivot turn can be done easily.

And, there is a little friction, and good running of the efficiency is possible so that a horizontal part may not do in area.

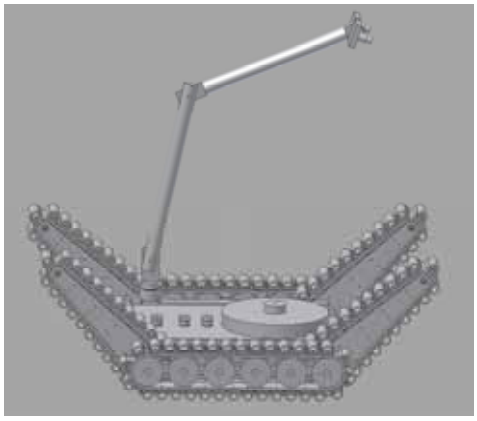


Figure -8　Move in flat ground

２）Move in the debris.（figure -9）

It runs under the condition that crawler of front and back is extended.

滑落 of the robot, influences on the suffering spot are reduced by reducing ground pressure of crawler.

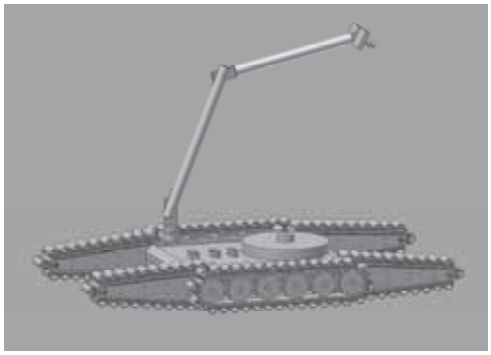


Figure -9　Move in the debris.

3）Traveling over the step.（figure -10）

It turns crawler of the back from the inside, and a body is realized by making it stand upright to travel a step .

The vertical step of maximum 40cm can be traveled .

Figure -10　Traveling over the step

4）Ladder climb （figure -11）

A ladder can rise by approaching in a posture like a figure.

The rubber of the midair which did a type D is being used for crawler of this mobile robot.

An offset has D pattern rubber as the figure -12 in the chain, and it is being installed.

A tip part is the structure which is easy to be applied to the edge by this.

And, because D pattern rubber sticks and it is arranged, ground pressure can be made small in the part of ground.

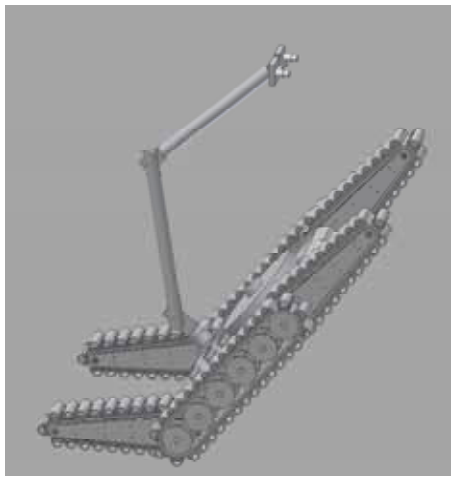


Figure -11　Ladder climb

5）Size of the robot

- Entire length : 854[mm]
- Width : 482[mm]
- Body height : 110[mm]
- Weight : 7.2 [kg]
- Maximum speed : 40[cm /sec]

Figure -12　Crawler which D pattern midair rubber was used

9. Other Mechanisms

9.1 5 DOF manipulator（figure -11）which a multi-sensor head was carried on

This mechanism is being developed for the purpose of the discovery of the victim and the information gathering for running of the robot.

The free occasion of the manipulator is as the next.

1）Sliding mechanism

It can be moved at the robot's own top in front and back 280mm.

A rack & pinion is used for the movement.

2）Turn base

It is equipped on the sliding mechanism.

HarmonicDrive is used with ± 200degree in the operating range.

3）The first arm

It is the arm of the length 300mm.

HarmonicDrive is used with ± 120degree in the operating range.

4）The second arm

It is the arm of the length 300mm.

HarmonicDrive is used with ± 120degree in the operating range.

る.

5）Turn head

A multi-sensor head is installed on the tip.

An operating range is driven by DC motor　with ± 200degree.

6）パンチルト mechanism of the sensor head

It hopes for the sensor head by the operator's demand on the turn in the level surface.

There is no relationship between this mechanism and the joint angle of the robot itself and the manipulator, and it can control the posture of the sensor head.マルチセンサヘッドを搭載した

Figure -13　5 degree of freedom manipulator which has a multi-sensor head

9.2 Automatic Ethernet wire wind device（figure -12） with the tension adjustment function

When it is moved in the debris, a wire injures the free occasion of the behavior.

On the other hand, it is very difficult to secure radio communication at the large-scale underground market and the big depth underground market.

And, the acquisition of the accurate information is difficult by the communication delay by more than one user, the noise, and so on.

It is the adoption of the form whose reliability is high to be important by the lifesaving.

So, we are developing the automatic wire wind device with the tension adjustment function which doesn't become a burden to the operator.

This system is composed of the next part.

1） Wire wind device

The flat type Ethernet cable of about 30m can be reeled.

2） An automatic tension adjustment mechanism and wire sending out mechanism

A wire is turned out continually if the tension of the wire is detected and it has tension.

And, if there is looseness, a wire is reeled automatically.

3） Slip ring

The slip ring which mercury was used for the tirl of the drum as is being used to secure the communication of 100Mbps.

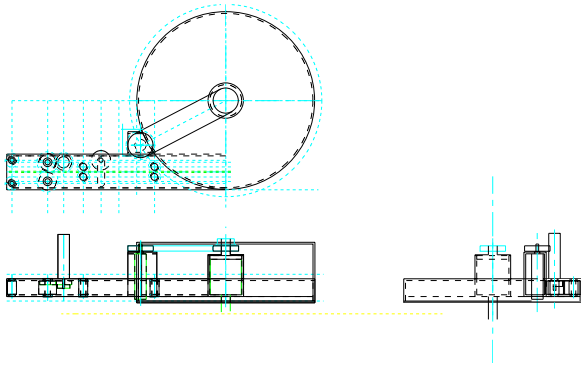


Figure -14　　Wire wind device

10. Team Training for Operation (Human Factors)

It is important that an operator gets accustomed to teleoperator to this robot.

On the other hand, many students are grasping these senses with a video game.

But, when it is operated in the actual environment, delay by the radio communication causes an important trouble.

Temporarily, even if delay time takes a limited time, correspondence concerning a moment becomes impossible, and a robot is decided environment to be given to it【 some damage 】, too.

Because such a scene is here, it insists on the cable with our system.

Well, though it is the plan of the training, I want to prepare the field which is a simple target within the campus.
So, after fundamental practice is finished, it considers going to the real experiment field.
An experiment field is in Kawasaki and Kobe, and that is used, and the training of the verification of the fundamental performance of the robot and the operation staff is given in Japan.

11. Possibility for Practical Application to Real Disaster Site

The high research theme of the actually useful practical use with the novelty is respected in the subject which we belong to.
There is a far stricter thing than a game field in the environment of the actual stricken area.
What kind of equipment is necessary against the equipment against the equipment against the leak, the poisonous gas, flammable gas, the radiant heat due to the fire, and so on, or we are doing verification.

12. System Cost

At present, there are a few things which we can introduce to the public very much.
But, all equipment will be equal at the end of March.
From now on, after system construction is finished, we will introduce all the information which contains the drawing of the robot to the public on the homepage.

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