# Hinomiyagura 2014 Team Description Paper for RoboCup 2014 Rescue Virtual Robot League

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**Abstract.** This paper describes our team's recent work and the research agenda for the RoboCup 2014 Rescue Virtual Robot League. We have two goal ; one of them is generating a map by multi-robot, the other one is making a test field to evaluate the performance of the response robot. Creating maps from data measured by mono-robot or multi-robot with ROS was described in a 2013 TDP of our team, and we find our previous solution which multi-robot's mapping is still insufficient. This year, we propose a method for evaluation of locomotion capabilities of rescue robots, and with a new test field for measuring the performance of the rescue robot on the uneven terrain. At last, the SLAM inaccuracy problem is discussed.

## 1 Introduction

Making maps of environments from robot's sending data is important for rescue operations to save human lives within limited hours. Then, to get the map in a short time, we should work multi-robot to generate a large area's map. At this time it is easy if there is a program to integrate maps, but these SLAM[1] do not have potential abilities for integrating maps into one. We could make a simple program for integrating several maps into a map by using ROS[9]. About integrating maps, the 2013 TDP of our team shows more details. When robots were on the flat floor, we could make some piece of maps into a large map. When robots were on the uneven floor covered debris, we could not get a correct large map. It is necessary to solve the problem of distorting the integrated large map. In this paper, we propose the test method to evaluate the response robot on the unstable situation. We show a test field to clear the reason of the error at making a large map from several piece of maps sent from multi-robot.

## 2 Background and Related works

When developing sensors and robots for effective search and rescue operations in disaster environments, testing robots at disaster environments helps us to

[1] http://www.ros.org/wiki/gmapping, http://www.ros.org/wiki/hector_slam

check improve the performance of the robots. The evaluation metrics for the performance of response robots are standardized by the National Institute of Standards and Technology (NIST) and the American Society for Testing and Materials (ASTM) International[10]. The test methods consist of the following items: mobility tests, wireless communication tests, manipulation tests, human-system interaction tests, and sensing tests. Mobility tests cover flat surfaces, terrains with pitch/roll ramps, terrains with step fields, inclined planes, and obstacles with gaps/stairs/landings. Sensor tests specify how well the videos work. As the mobility tests proposed by NIST and ASTM indicate, it is normal for response robots to move on floors with ramps and steps. Disaster City has several fields that simulate real building collapses[4, 5]. These fields are examples of real cases, and used to check the mobility of robots. NIST test fields have been used in RoboCup Rescue competitions. A NIST test field is composed of $1m^2$ units from one big test field. This is used to fix the unit length at 1 m and makes locating the positions of victims and making a map easier than in real situations.

In the virtual robot competition of RoboCup Rescue, USARSim has been used as a platform[3]. USARSim is configured based on the Unreal Tournament game engine and provides a high-fidelity simulation of robots by creating 3D environments and emulating wireless communications and other sensors, which make the simulations more realistic. The test fields cover the inside and outside of buildings, along with city and field scenarios, and different types of robots have been used in the competitions[1].

The simulated evaluation field can be used as well as the real one. In some case, the simulated one is better than the real one. For example, to set a configuration for a Wi-Fi situation in the real environment is difficult, but it is easy to configure a simulated Wi-Fi situation by using a software Wireless Simulation Server (WSS)[8, 7]. We submitted a paper about a proposal of a method for a simulation of diffracted Wi-Fi wave propagation to the RoboCup 2014 Infra Structure League.

## 3 System overview and Experiment

Our system is consist with USARSim, including WSS, and ROS[2]. We use ROS for robot's controller, SLAM and other modules. Human Operator gets information of camera view and whole map, and commands of robots. ROS is running on Ubuntu, receive information of range sensor and so on from a robot in USARSim, and output a map data published by SLAM algorithm. Also ROS directs a robot by human operator's command. One Ubuntu and ROS system is allocated to one robot. Each map data outputted by ROS are integrated, and the result as a whole map is shown to an operator. Similarly the image of the camera attached to each robot is shown to a human operator. Basing on information of the whole map data and these image, operator command robots through the command translation program. Ubuntu version is 12.04, and ROS version is FUERTE.

### 3.1 Proposed Method and Test Field

We proposed a method for how to make a reproducible simulated disaster field. We made a floor which were covered by debris with our proposed method. The debris were approximately same size as the robot's body. Debris is a major component that causes uneven terrain[6]. This debris can consist of furniture, parts of buildings, and other material. The size of the debris differs, and the debris may pile up in diverse ways. For example, the situations inside Fukushima Daiichi Nuclear power Plant(FDNP) differ from those found in the test fields in Disaster City. A triangular prism is used as a fundamental component to represent the surface of uneven terrain. The prism has three parameters:the width, length and height. It represents a floor with a slope when the width and length are larger than height, and represents steps when height are larger than the width and length. Placing various triangular prisms on a floor creates an uneven floor and forms the patterns of the NIST test field[10].

**Table 1.** Height of Leveled Ramps and Robot dimensions. h is the height of the prism. The width of the prism is 1 m.

| Level | $h$(m) | Angle (degree) | $\frac{Length_{Robot}}{Length_{Ramp}}$ | | |
|---|---|---|---|---|---|
| | | | P3AT | Kenaf | |
| | | | | Horizontally Crawler arms | Vertically Crawler arms |
| 1 | 0.000 | 0.000 | 0.520 | 1.200 | 1.808 |
| 2 | 0.040 | 4.576 | 0.518 | 1.196 | 1.802 |
| 3 | 0.080 | 9.095 | 0.513 | 1.185 | 1.785 |
| 4 | 0.120 | 13.503 | 0.506 | 1.167 | 1.758 |
| 5 | 0.160 | 17.754 | 0.495 | 1.143 | 1.722 |

The height parameter of the prisms refers to the dimensions of robots: P3AT and Kenaf, which are wheel-type and crawler-type robots, respectively (Table 1). Table 1 shows the appropriateness of the $h_1$ and $h_2$ parameters based on $\frac{Length_{Robot}}{Length_{Ramp}}$. Our experiences in RoboCup Rescue tell that, when $\frac{Length_{Robot}}{Length_{Ramp}}$ is close to 1.0, a robot can hardly move. P3AT's $\frac{Length_{Robot}}{Length_{Ramp}}$ values were under approximately 0.5. The angles given in Table 1 were under 30 degree($h$ is under 0.288), and we could control the robot well. Those meant P3AT could move on prisms at levels 1∼5 in our proposing field(Figure 1).

### 3.2 Experiment

Most rescue robots use SLAM , because the environment is so damaged that a map has to be made from scratch. We had an experiment with our proposed field to measure how much bad effect an uneven floor to get the result of SLAM. We

**Fig. 1.** This figure shows uneven floor consisted from prisms and a robot P3AT. The P3AT can run over prisms easily in this combination the size of the robot and the prism.

made a room which size is 10 m by 10 m for this experiment in the USASRsim. We used a robot P3AT equipped a simulated SICK LMS200 for this experiment. The floor is covered with triangular prisms which width is 1 m and length is 10 m. The result of this experiment said:

1. Hector SLAM outputs data with more error with bigger angle of ramps.
2. Gmapping SLAM using odometer data is more stable than Hector SLAM.

On the uneven floor, SLAM output decrease it's accuracy. That is why, the previous experiment only illustrated the difficulty to combine measurements in an environment with ramps. No evidence is given about the difficulty to combine measurements from multiple robots. One of our purpose is not evaluating SLAM methods, but provides test fields for checking robots' performance including mobility and sensing. Our test field can be used to check the robots' mobility and sensing combination performance.

## 4 Discussion and Future works

We proposed a method for making the test fields for response robots. We showed the necessity for test fields in experiments involving the generation of maps by SLAMs. Indeed, SLAM results from a flat floor can be understood by humans, but SLAM results from an uneven terrain suffer from distortion and are more difficult to be understood by humans. Therefore, test fields are needed to evaluate the response robots, range sensors, and SLAM algorithms.

Robots are expected to be used in various situations for different purposes at the Fukushima Daiichi Nuclear Power Plant. For example, robot systems composed of hardware and software are expected to perform various tasks-from surveillance and create maps outside and inside the buildings to the construction of pipes and equipment. Robots are expected to be designed for these uses and verified.

Our proposed test fields are expected to be useful as methods for evaluating the performance of present and new sensors, algorithms, operators, and rescue strategies. The performance test fields for robots need to be standardization for the purpose of providing common evaluation tools for the researchers, developers, and customers of response robots.

When we integrate maps which have some level, stairs or grade separated crossing, we should consider both plane and vertical direction. The reason is that robots and members of rescue team need a cubic map with 3D information, accurately records the result of search in building, as common information source. In the future, we extend the study area, approach SLAM algorithm and develop the system which records the cubic map.

## 5 Release Schedule

We can release our proposing simulation system on our web site by the end of June 2014.

## References


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