Hinomiyagura 2016 Team Description Paper for RoboCup 2016 Rescue Virtual Robot League

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Abstract. Robots have been used to explore the interior of the Fukushima Daiichi Nuclear Plant (FDNP) that was destroyed by the tsunami. Robots are supposed to be used for decommissioning of FDNP over the next several decades. There are many types of works that we should do use robots instead of human workers. Especially, for human healthy conditions, the robots are expected to do routine works in addition to exploration at FDNP. In this paper, we propose a new mode, diffraction, in wireless communication model. The function supports the remote operability of robots at the fields like FDNP.

1 Introduction

Since the 2011 Great East Japan Earthquake, robots have been used to explore the interior of the Fukushima Daiichi Nuclear Plant (FDNP). At FDNP, robots are supposed to do tasks: clear debris, monitor and map the inside and outside of buildings, setup instruments, shield and decontaminate, transport material, construct pipes and equipment, etc. [2]. It is necessary to design new mechanisms and develop sensing algorithms to meet the mid and long term schedule to decommission FDNP.

Our team, Hinomiyagura, have proposed standardizations for robot tasks and training environments for robot operators to fill the needs for checking and the operating of robots [7]. This year, we propose a new evaluation environment example with unstable Wi-Fi connectivity with diffraction phenomena in the Gazebo robotic simulator.

2 Background and Related works

The RoboCup Rescue project has been held every year with one objective: to promote research and develop topics related to rescue robots [5]. Quince, a robot that has participated in the RoboCup Rescue competition, was actually applied at FDNP, demonstrating it's performance by exploring the disaster areas [9]. They tested Quince's ability in a test environment that was constructed based on the data presented by TEPCO before they used Quince in real situations.

In the virtual robot competition of RoboCup Rescue (VRRCR), USARSim has been used as a platform. 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. Simulation systems such as VRRCT, provide platforms that functions of rescue robots and algorithms are tested for disaster areas where they will operate.

Pfingsthorn provided Wireless Simulation Server (WSS) in the VRRCR to simulate wireless network links in a disaster setting [4]. While the wireless network is one of key components to control robots, the WSS have remained the same one as Pfingthorn provided. As Pfingsthorn pointed, participants of VRRCR are forced to deal with issues of wireless links, such as limited range and the resulting need for either multi-hop routing or temporary autonomous behavior.

The nuclear plants at FDNP are decided to decommissioned and the decommission process will take a long time. As well as the decommission task, there are tasks in everyday operations that robots are supposed to do. For example, water contaminated with radioactive materials is stored in tanks that are located in the outside of FNDP. The tanks are fenced to reduce the risks of rainwater overflowing from fences around the tanks. Because the leak of the water was previously detected within the fences, an investigation by human has been conducted to check for any leak of rainwater from the fences. We think the investigation task is one of routine tasks and is easier than that the rescue robot, Quince, explored inside buildings in FDNP at 2011.

3 Future Robot Tasks at FDNP

3.1 Investigation tasks of around tanks

Figure 1 shows a picture of tanks. The tanks were constructed in the FDNP to store water that was used cool the nuclear fuel of FDNP. The tanks are placed systematically in the FDNP and the size of the height and diameter of the tank are 10m and 12m respectively and the area is 100-meter size wide. Figure 2 shows an image of VRRCR's environment to investigate the tanks and the area. The small black dot in the center of the figure is P3AT robot. The investigation task is to move around the tanks and to check the the conditions of inside and outside of the fences.

It is assumed that the robots are operated remotely to cope with unexpected accidents. In a case of wired connection, tracking cable limits the range and movements of robots operations. In a wireless connection, tanks become obstacles for propagating of radio wave. A hybrid system of the wired and wireless connections is one of practical solutions that. The hybrid system was used in the exploration tasks of a building of FDNP. A pair of Quinces, one of the pair was connected with a cable and worked as access point of wireless system. One robot issue is connected via wireless system. The pair of Quinces was connected stably and acquired its mobility.

Fig. 1. Tanks in the Fukushima Daiichi Nuclear Plant. The tanks are used to store contaminated water.

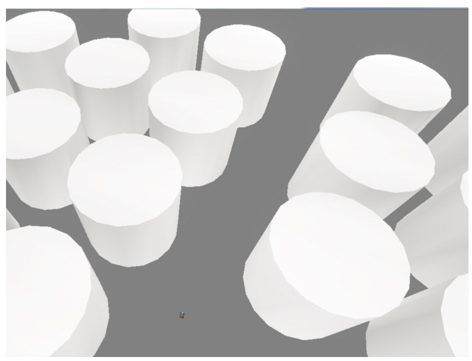


Fig. 2. Tanks and a robot in virtual Fukushima Daiichi Nuclear Plant. The black dot in the center is P3AT robot.

3.2 Wireless transmission models

The WSS provides two transmission models; propagation and non-propagation models. The propagation model supports attenuation of signals between two connecting stations. The radio wave goes straight with following phenomena.

- signal attenuates with distance,
- absorbed by objects,
- reflected by objected,
- diffracted around corners,
- fluctuated by multipath.

After the reflection and the diffraction, the radio wave goes straight again. A past WSS (version 0.61 at 14.2.2014) has two wireless transmission modes and simulates the phenomena of radio wave.

Distance Mode: This mode calculates the distance between a base station and robots that communication with each other. When the distance is longer than a threshold value set in advance, the WSS cuts the wireless communication between them.

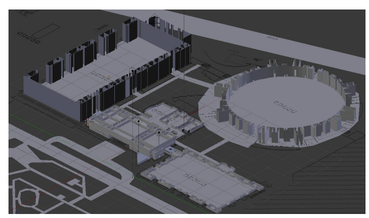
Obstacle Mode: This mode checks whether there are objects on the straight line between two of a base station and robots. When there is an object on the line, the WSS cuts the wireless communication between them.

4 Wi-Fi test environment proposal

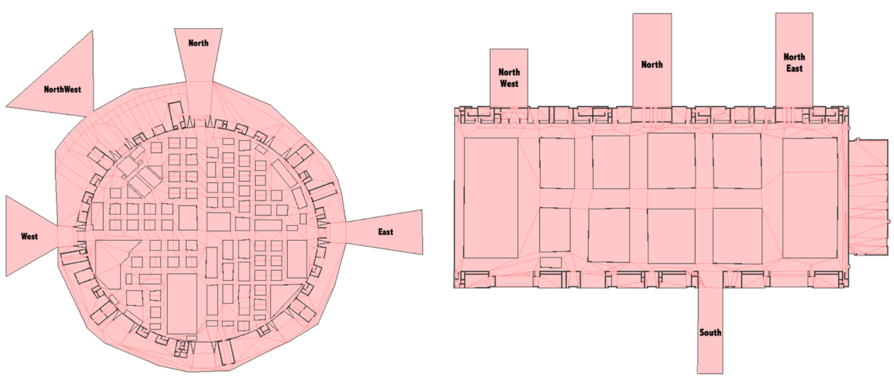
4.1 3D model of RoboCup 2017 Venue

RoboCup 2017 will be held in three halls of Portmesse Nagoya. Fig. 3 (a) shows the overview of Portmesse Nagoya. Fig. 3 (b) is a 3D model of the halls and the road around the venue. Fig. 3 (c) represents the floor layout of Halls 1 and 3. The figures illustrate an exhibition state of halls. The boxes in the figures are display spaces and small rooms for exhibitions. The box areas straiten movements of people in the hall. In contrast, people can go in any preferred direction in an open space state where there are no displays.

(a) An overview of Portmesse Nagoya



(b) 3D CAD model



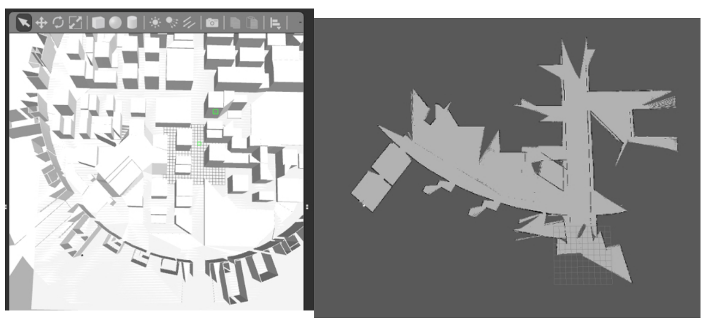
(c) Hall 1 and Hall 3 with display layouts.

Fig. 3. RoboCup 2017 venue. Nagoya International Exhibition Hall (Portmesse Nagoya)

4.2 Rescue virtual robot competition: sensing and vulnerability

Rescue robots participating in the RCRL are expected to demonstrate their functions in case of an emergency occurs at the RoboCup competition sites. The robots are tele-operated from the outside of the building, and they explore the situation inside the halls. Fig. 4 (a) and (b) show the 3D images of Hall 1 with displays of a past event and output from SLAM simulation results using ROS platform [6].

The area size of the hall is about 100 m in terms of length. The simulation size yields specific values in accordance with the tasks at the Fukushima Daiich Nuclear Power Station when rescue robots were used to explore the interiors of the buildings [3, 1]. The simulation results of the size and the real layout imply that the test bed created according to the 2014 proposal provides a realistic environment to verify the mobility and sensing abilities of the rescue robots.



(a) Layout with displays in the model of Hall 1 (b) Output of hector_SLAM

Fig. 4. Hall 1 with displays and output of SLAM

4.3 Provision of a more realistic environment for exploration tasks

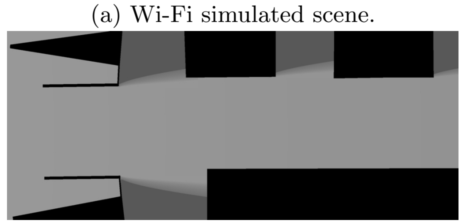
The Portmesse Nagoya simulation model is prepared based on of the details of the test bed provided for the rescue robots. The robots are expected to investigate in the hall in order to search for missing victims, check damages and generate maps after the disasters by using the environment (Section 4.2). It assumes that most of robots in the disaster area are tele-operated from the exterior of building and transmitted the sensing data to the operators outside with stable and reachable WiFi connections. In rescue robot league, NIST test standards have been used to estimate the performance of robots. The standards do not specify variations in wire strength.

Fig. 4 (a) shows that there are displays in the area. It is well known that the walls of the displays affect the strength of the Wi-Fi received by the robots receive, and moving obstacles make the signal weak and unstable.

These radio disturbance sometimes resulted in situations where the WiFi signal does not reach the robots. In exploring the FDNP buildings, a robot pair was used to ensure a stable connection to the operators [3]. A robot connected by a cable acted as a wireless access point. The second robot was operated wirelessly. The collaboration of the robots enables the second robot to explore the building interiors widely and freely under stable WiFi conditions. Hence, simulating the WiFi signal strength makes the environment more realistic.

The simulated environment can give estimated Wi-Fi power strength at a point receiving Wi-Fi signal[8], every rescue robot which is controlled with Wi-Fi can be evaluated in unstable Wi-Fi condition. Fig. 5 (a) is a close up of around a gate of 4 (a) . A white box of left side of Fig. 5 (a) is a Wi-Fi base station which located at 90 m far from the gate. Fig. 5 (b) shows a result of simulated Wi-Fi received radio power strength with diffraction phenomena of radio-wave. Fig. 5 (b) shows obstacles extracted from the field model by using Gazebo AIPs as black colored pixels and the gradation of color in the corridors show the power of Wi-Fi. The dark area show diffracted Wi-Fi reach robot , even though the power is weak. Where the simulated Wi-Fi power strength is under -92 [dB], a robot which be stepping into there must use an autonomous mode until escape from the Wi-Fi unstable area. The robot's autonomous program will be able to be evaluated with more realistic situation.

(a) Wi-Fi simulated scene.



(b) A result of simulated strength of received Wi-Fi power.

Fig. 5. A simulated Wi-Fi signal power strength

5 Discussion and Summary

In this paper, we showed more capability of simulation environment for evaluation of rescue robots in unstable Wi-Fi environment with Gazebo. Taking investigation tasks in unstable Wi-Fi areas, we showed a sample environment to evaluate ability of rescue robots which will do instead of human workers with more realistic situation. The tasks are not limited in a kind of rescue and search in disaster area. We think such tasks will increase as the process of decommissions at FDNP and realistic simulation module of wireless communication will become one of key issue simulation environments.

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