Quince: Monitoring Robot for Disaster Response in the Fukushima-Daiichi Power Facility

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Back in 1995, the Great Hanshin Earthquake hit the Kobe city in Japan. After the earthquake, some research and development (R&D) projects have been started for robotic disaster response. Mobile robots, called Quince, were developed in one of such projects. Quince robots were small tracked robot for assisting first responders in search and rescue missions in dangerous environments, particularly disasters in underground malls. In 2010, R&D on Quince was almost at the final stage, and evaluated with several tests in fire departments. Meanwhile, on March 11, 2011, Fukushima Nuclear Power Station was damaged by the Great East Japan earthquake and the accompanying tsunami. Three reactor buildings were seriously damaged and radioactive materials were released. It was not known whether it was safe to enter the buildings or not, and robotic surveillance missions were highly demanded. Therefore, just after the disaster, our retrofit project of Quince was started for operations in the reactor buildings in a joint effort with the Tokyo Electric Power Company (TEPCO).

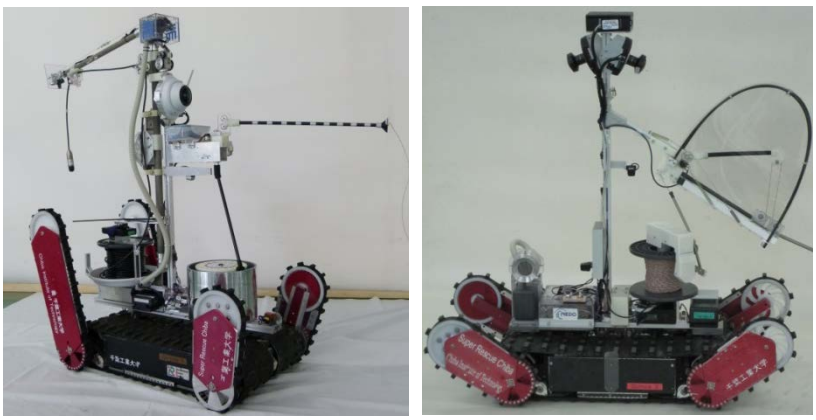

Fig1. Quince1 (left) and Quince2 (right)

The first robot Quince1 was deployed to the site on July 20, 2011, and used until October 20, 2011. In the period, six missions were conducted, and status of facilities and pipes were confirmed by the information gathered. It contributed very much to restoration work planning. However, on October 20, Quince1 did not come back in a surveillance mission in the reactor building, Unit 2. On the returning way, the communication cable was damaged and the robot was abandoned on the 3rd floor.

The second set of robots, Quince2 and Quince3, were deployed on February 20, 2012. These robots were developed based on the lessons learned from Quince1, and they are still working in the disaster site. Until now, TEPCO accomplished total 13 surveillance missions in the reactor buildings conducted by these robots.

To utilize the Quince in the reactor buildings, the following three matters should have been satisfied:

1) Hardware: fundamental abilities to explore the reactor building,
   The fundamental abilities are radiation tolerance, communication system for teleoperation, mobility and reliability. The radiation tolerance of the electrical components on Quince was investigated by the gamma ray irradiation test, supported by the Japan Atomic Energy Agency (JAEA). According to the result, we concluded that no special shielding was required for basic components of Quince. For communication, wireless communication devices were examined at the Hamaoka Nuclear Power Plant. Based on the result, we gave up using the wireless communication system, and mounted a wired communication system with a cable handling device on the Quince. Mobility was verified by testing with mockup stairs that has designed based on actual stairs in the reactor building.

2) Sensors: mounting instruments for achieving surveillance tasks
   Instruments mounted on the Quince to achieve surveillance tasks include high-resolution cameras, a dosimeter, lighting system, and even a simple manipulator for handling a probe of water level gauge. After Quince1 was used on the site, a thermometer and an air dust sampler were requested from the TEPCO. Therefore Qunice2 and Quince3 were equipped with these devices.

3) Software: good design in consideration with the extreme condition
   Typically, workers at the site wear full-face mask and gloves over other gloves. Handling a set of console of the robot must be operable with such equipments. Therefore, a small and tough PC was used for operator console, and the teleoperation software was developed for displaying multiple images and information on a single screen.

In this presentation, I would like to present our development story of Quince, and introduce what happened in the robotic surveillance.