Robotics in infrastructure maintenance

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Summary of R&D on robotic technologies

Robotic technologies and information communications technologies play an indispensable role in the inspection and maintenance of infrastructure that is not easily accessible to people, and in surveying disaster sites and emergency restoration. Therefore, in the area of "infrastructure maintenance, renovation, and management technologies" in SIP, we are engaged in research and development on maintenance technologies using flying robots and other mobile robots, technologies for unmanned operation of construction equipment for emergency disaster restoration, and elemental technologies for those purposes, as well as databases for the effective utilization of robotic technologies. In this paper, we will summarize the R&D projects related to robotic technologies that have been implemented by SIP up to FY 2016. Please refer to the literature for further details concerning each project.[(1)]

R&D on maintenance technologies using flying robots

Bridges and tunnels are currently inspected manually, and this work is quite time-consuming and costly because it requires the installation of scaffolding and the use of inspection vehicles. In addition, some portions are not easily accessible by people, and this involves danger in some cases. For these kinds of inspections to be performed using robotics, based on the procedures for bridge inspections and tunnel inspections, it is necessary for technologies to replace or support people in performing close visual inspection and hammering tests. In R&D

on robotic technologies in the SIP Infrastructure Program, research and development on the use of flying robots and maintenance is being pursued by several research institutions.

Because flying robots require to operate safely in close proximity to bridges and tunnels in order to inspect them, various measures need to be devised in terms of hardware configuration, flight control, and inspection operations. As a way to address this problem, research and development is underway on the use of drones in a flying robot system that can substitute for people in performing hammering tests and close visual inspection of bridges. The multirotor craft inside this flying robot is covered with a light spherical shell made of carbon and supported by a gimbal (rotating support). While it is flying, the outer shell comes into contact with the object being inspected, so the multirotor craft inside it can perform close visual inspection without touching the surface of the bridge or tunnel (Photograph 1). In addition, there is R&D on a flying robot system for hammering test inspection of bridges and tunnels in which a hammering device attached to the multirotor craft can be pressed against the wall of the object being inspected to perform a hammering test, an inspection system based on a flying robot that is pushed against a wall while moving on four-wheels for close visual inspection and hammering tests, etc., and a robotic system that uses a two-wheeled multirotor craft to support vertical inspection of bridge pier.

Photograph 1. A spherical multirotor craft inspecting a bridge.

R&D on maintenance technologies using robots that move on guides

The use of flying robots to inspect bridges and tunnels has the advantage of eliminating the need for inspection vehicles and other large-scale equipment, but there are some problems with this approach, such as the inability to conduct inspection work in strong winds, and flight time limitations. Therefore, research and development is underway for robots that move along a guide, making it possible to inspect bridges and tunnels without traffic restrictions such as road closures. For bridge inspection, there is R&D on a bridge inspection robot system supported by freely adaptable horizontal supports, in which four hanging wires are installed on the underside of a bridge and an inspection robot is hung from the wires, controlling the length of wire that is sent out so that the robot can perform close visual inspection of floor slabs and hammering tests. In addition, there is R&D on a system for full cross-section inspection and diagnosis of tunnels, in which a flexible guide frame makes it possible to

perform close visual inspection of floor slabs and hammering tests while avoiding projections such as tunnel jet fans and signboards.

Development of remote-controlled robotic technologies for disaster response

For landslide disasters that result from heavy rains, the use of remote-controlled construction equipment for removal and transport of mud and rock is expected. Backhoes that can work in water already exist, but there is no semi-submersible transport equipment that can carry away the mud and rock in combination with the submersible backhoe. Therefore, a remote-controlled semi-submersible heavy load tracked-transporter has been developed which can be submerged to a depth of 1.8 m and has a load capacity of 10 tons (Photograph 2). In addition, to make the operation of these kinds of remotely operated robots more intuitive, we are also pursuing research and development on a man-machine interface that is suited to the characteristics of the person operating it.

Photograph 2. Remote-controlled semi-submersible heavy load tracked-transporter.

R&D on environment structuring and developing a unified database

Along with R&D on robotic technologies for infrastructure maintenance and disaster response, R&D is also underway on developing an infrastructure to make it easier to introduce robotic technologies (structuring the environment). We are also engaged in technical development aimed at commercialization of the robotic technologies that are expected to be utilized in infrastructure maintenance and disaster response, and we are developing a system to unify robotic information for infrastructure with the purpose of promoting utilization after commercialization. It is anticipated that these endeavors will help to accelerate the introduction of robotic technologies in the field.

Improving the safety and efficiency of maintenance and disaster response will be essential in the practical implementation of the robotic technologies described in this paper. In the future, it will be important to introduce the developed technologies into the field on a test basis, provide feedback to research and development based on the results of these endeavors, and use that feedback to improve and enhance each of these technologies.

References

(1) Infrastructure maintenance, renovation, and management technologies, http://www.jst.go.jp/sip/k07_kadai_dl.html