R&D Item

7. Technologies for responding to river channel blockages

Progress until FY2024

1. Outline of the project

This project aims to enable infrastructure construction in diverse environments using a collaborative AI robot system, with a focus on applications at natural disaster sites involving river channel blockages. To this end, we are advancing R&D in three areas: (1) System integration for emergency surveys of river channel blockages, (2) System integration for emergency restoration work of river channel blockages, and (3) Technologies for responding to river channel blockages. The system integration for emergency surveys and emergency restoration work aims to facilitate the early social implementation of disaster response technologies. At the same time, foundational research is also essential to ensure that these systems can adapt to diverse environments. With this in mind, our project is conducting R&D focused on proof-of-concept for next-generation robotic systems, particularly designed for addressing river channel blockages.

2. Outcome so far

This research and development initiative focuses on robotic technologies that can flexibly respond to various scenarios, with the goal of enabling effective recovery operations for river channel blockages. Below, we introduce the main achievements from fiscal year 2024.

For the installation of drainage pumps—a key part of the system integration for emergency river channel blockage—Kumagai Gumi has proposed a system using compact construction equipment, as shown in Figure 8. However, this approach may not be feasible in areas with unstable ground conditions. In response, a research group at Osaka Institute of Technology has developed a modular transport container system called “BRAINS.” This system allows the working unit and the mobile unit to be separated and reconnected as needed, making it easier to adapt to changing conditions at disaster sites. The container is divided into two levels: the upper level houses the working unit, while the lower level contains the mobile unit. By swapping out mobile units according to the site environment and recombining them with the working unit, a wide range of construction robot configurations can be realized. In 2024, the team successfully created a scale model of this concept and conducted functional tests in an indoor environment. Figure 9 shows an overview of the BRAINS container enabling the separation and recombination of the mobile and working units (top left), the d-FlexCraw mobile unit designed for rough terrain (top right), and the i-CentiPot Ammonite working unit used for hose deployment (bottom). In this figure, the hose-deploying working unit is mounted on a standard crawler-type mobile platform.

Figure 9: An overview of the modular transport container "BRAINS" that enables separation and recombination (top left), a mobile unit to traverse challenging terrain (top right), and the working unit designed for hose deployment (bottom).

Meanwhile, for excavation work in earthmoving during the construction of temporary drainage channels, hydraulic excavators are currently used. To replace the excavators, we are conducting R&D on new excavation methods that would allow this task to be performed by multiple small construction robots. Specifically, we aim to establish an excavation technique using two compact robots, by dividing the excavation process into two functions: loosening and scooping. In 2024, we successfully automated each step of this process: one compact construction robot used a chiller (a ground-loosening tool, shown in the top left of Figure 10) to loosen the soil (top right), while a separate skid loader collected the loosened soil.

Figure 10: Loosening of the ground using a chiller and soil collection by compact construction robots

In addition to this, we also advanced research on dynamic cooperative control technologies for multiple construction robots working together to respond to river channel blockages. Furthermore, we developed AI-based learning methods for excavation strategies that can adapt to varying ground strengths.

3. Future plans

The goal of this project by 2030 is to enable infrastructure construction in diverse environments, including those affected by natural disasters. To achieve this, the current R&D theme focuses on foundational research that supports adaptability to a wide range of environmental conditions. By the end of the project in 2025, we aim to verify the effectiveness of each technology and reach Technical Readiness Level 4 (TRL4), where the basic functions and performance of the technologies and systems are demonstrated in a controlled environment.