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Motion Analysis of Radioactive Material Sampling Using a Dual Arm Robot in High Radiation Area

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1. Introduction

High radiation areas, such as decommissioned nuclear facilities, are difficult for workers to access due to the high risk of radiation exposure. It is necessary to conduct environmental surveys by collecting and analyzing radioactive samples of soil, surface materials, and objects from nuclear facilities. However, currently, most of the sample collection tasks are conducted by human workers in the radiation zone. Therefore, the development of robot-based radioactive sample collection technology is required to minimize the risk of radiation exposure to workers and increase the efficiency of sample collection in high radiation areas.

In this study, we discuss motion analysis for verifying soil and surface sample collection scenarios using a dual arm robot in high radiation areas.

2. Motion analysis

In this study, we performed motion analysis using the 3D model of the dual-arm robot, ARMstrong to analyze radioactive material sampling operations in high-radiation areas. Based on the 3D URDF file of the ARMstrong robot, motion analysis was conducted by analyzing the work space of the joints, as well as the interference and contact between parts during operation.

2.1. Soil sampling motion analysis

ARMstrong is a dual-arm robot with a total of six degrees of freedom in each arm. To enable soil sampling with a single arm, the following soil sampling scenario was designed:

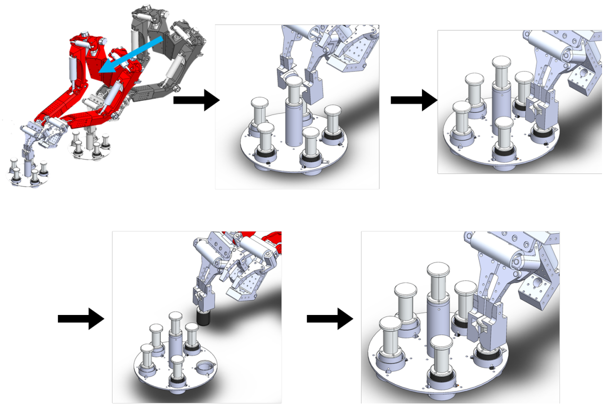

Fig. 1. Result of soil sampling motion analysis

1. Move the soil sample storage container to the high-radiation area.
2. Place the soil sample storage container on the ground.
3. Attach the soil sampling equipment.
4. Perform soil sampling.
5. Place the soil sampling equipment to the soil sample storage container.
6. Repeat the same soil sampling process five times.

In this analysis, the top position of ARMstrong was assumed to be 1.2 m above the ground level.

2.2. Result of soil sampling motion analysis.

The motion analysis result for the soil sampling process is shown in Fig. 1. Through this motion analysis, it was confirmed that the robot can perform the task within the joint workspace. This analysis also provided the foundational data necessary for future outdoor testing.

2.3. Surface sampling motion analysis

To enable the ARMstrong robot to perform surface sample collection in a high radiation zone, the following surface sample collection scenario was designed:

1. Move the surface sample storage container to the high radiation zone
2. Place the surface sample storage container on the ground
3. Attach the surface sample collection equipment
4. Perform surface sample collection
5. Place the surface sample collection equipment to the soil sample storage container
6. Repeat the surface sample collection procedure five times using the same method

In this analysis, the top position of the ARMstrong robot was assumed to be 1.2 m above the ground, which is the same as for the soil sample collection procedure.

2.4. Result of surface sampling motion analysis.

The motion analysis results of the surface sample collection procedure are presented in Fig. 2. Based on the analysis, it has been verified that the ARMstrong robot is capable of executing the task within the joint workspace range. Furthermore, this analysis provides fundamental data for conducting outdoor testing in the future.

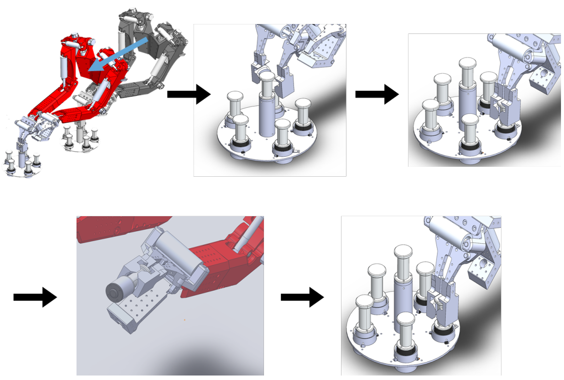

Fig. 2. Result of surface sampling motion analysis

8. Conclusion

In this paper, motion analysis was conducted for soil and surface sample collection using a robot in a high radiation zone. A scenario was designed for the utilization of sample collection equipment, and motion execution was performed to assess the suitability of the scenario. In the future, the effectiveness of unmanned sample collection will be verified through actual soil and surface sample collection tests using a robot.

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