An Approach to Reconstruct Digital Mockup Based on Three-dimensional Scan Data for Nuclear Dismantling Process Evaluation System

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1. Introduction

In order to solve the problem of the difference between the digital mockup of the dismantling facility and the actual field environment, it is necessary to update the digital mock-up of the facility to be cut based on the real-world three-dimensional information. In this study, a methodology for solving these issues was developed and implemented as a unit module of the existing dismantling process simulation and integrated evaluation system.

2. Research Method for Digital Mockup Reconstruction

We examined the digital mockup update methodology that applies the transformation matrix obtained by comparing the difference between two models on the point cloud based on the CAD model composing the digital mockup and the 3D scanned environment information characteristic to the CAD model. In addition, we developed a framework by applying various point cloud processing technologies to improve the accuracy and speed of updating digital mockups, and also tested the system based on real industry data.

3. Two-step Reconstruction for Digital Mockup

In order to compare the digital mockup with the CAD model to the point cloud model of the dismantling site obtained by 3D scanning, point sampling was first performed in the CAD model. The point sampling method applied in the CAD model is to generate a point cloud by performing Poisson Disk Sampling on all faces of the mesh model of each part of the CAD model created using the tessellator provided by the CAD kernel. In addition, in order to improve the matching speed and accuracy, the extended bounding box of the extracted point cloud was cropped in the point cloud of the scan model and the point cloud extracted from the CAD model was matched to the cropped scan model.

Generally, Iterative Closest Point (ICP) is widely used as a method for precise registration, but the ICP method is very sensitive to the initial conditions and ICP cannot be performed if there is no overlap between these two point clouds. To overcome these drawbacks, this study added a first registration procedure to derive the initial conditions of ICP. In the first registration process, key points that best represent the model shape were extracted from each model, and feature values were calculated using Fast Point Feature Histogram (FPFH) method at each keypoint.

Based on these calculated feature values, the first registration was performed using the Sample Consensus Initial Alignment (SAC-IA) method. For secondary registration, the first registration result was applied to the point cloud extracted from the initial CAD model, and then the point cloud was registered with the scanned point cloud using ICP. Finally, the CAD model was updated by applying the transformation matrix for initial registration and the transformation matrix for precise registration to the CAD model.
Fig. 1 shows the overall framework of the methodology for digital mock-up reconstruction, outlining the process of sampling the point cloud for each part of the CAD model, registering the 3D scanned point clouds, and updating the results back to the CAD model. The scanned point cloud increased registration speed and accuracy by using only the cropped portion of the bounding box area of each part.

4. Conclusion

The digital mockup reconstruction methodology that has been set up was applied to the dismantling process evaluation system through modularization. In the future, we will improve the performance through sufficient test and evaluation. Through this, the technology to reflect the environmental information of the decommissioning site in real time on the dismantling process evaluation system and remote cutting system will be developed.

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REFERENCES