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Environmental Information Feedback Framework for Nuclear Facility Decommission

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1. Introduction

The dismantling of nuclear facilities takes a very long time and is a dangerous procedure. Thus, it should go through a process optimization procedure based on the process simulation. The process simulation pre-evaluates the operation time and cost, and predicts the possibility of danger during the dismantling process, thereby enhancing the safety of the dismantling [1].

And we are developing a system that performs cutting operations based on the scenarios created in the simulation system. However, existing CAD models and actual sites may differ, so that cutting activity in the scenario which is created based on the existing CAD models can be inapplicable for actual cutting operations.

So we need to acquire the actual site data and apply appropriate feedback to the simulation system to find out if there are changed parts of the existing CAD models from the real sites and then we update the models and dismantling scenarios.

As laser scanners become widely used in 3D data acquisition of industrial sites [2], we use a 3D laser scanner to acquire the real site data. The format of feedback data from the scanner is a 3D mesh model.

In this study, we present overall framework of the environment information feedback system and evaluate the framework based on the result from the experiment with our test bed.

2. Methods and results

The overall scheme of the environment information feedback framework is shown in Fig. 1. The framework is composed of the laser scanning module, alignment module and the simulation system. The simulation system controls all the other modules in the frameworks.

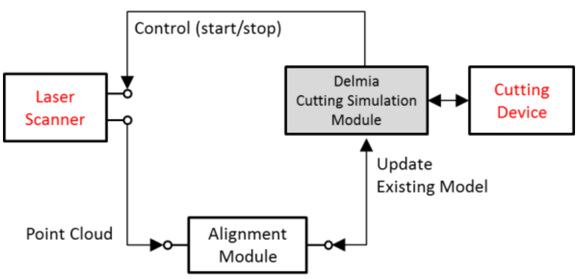


Fig. 1. System structure.

In-situ model is generated by the laser scanner and its control module. Scanned model is matched with existing CAD model and based on the result, the CAD model is updated.

2.1 Laser scanning

The laser scanner scans geometry of the actual site and builds the 3D mesh models by which the existing CAD models are updated.

The laser scanner continuously scans target geometry into a point cloud. We perform registration and merging operations to the scanned point clouds and perform additional refinements to the merged model (remove outliers, hole filling and etc.) to enhance the quality of the model, and then we get the 3D mesh model of the actual site (in-situ model).

2.2 Model alignment

The scanned 3D mesh model is aligned with existing CAD models to update the existing models. For the alignment process, both models should be in same format, so that we convert CAD model into 3D mesh model. Since exiting CAD model contains much more information than mesh model it is easier to convert CAD model into mesh model than to convert mesh model into CAD model.

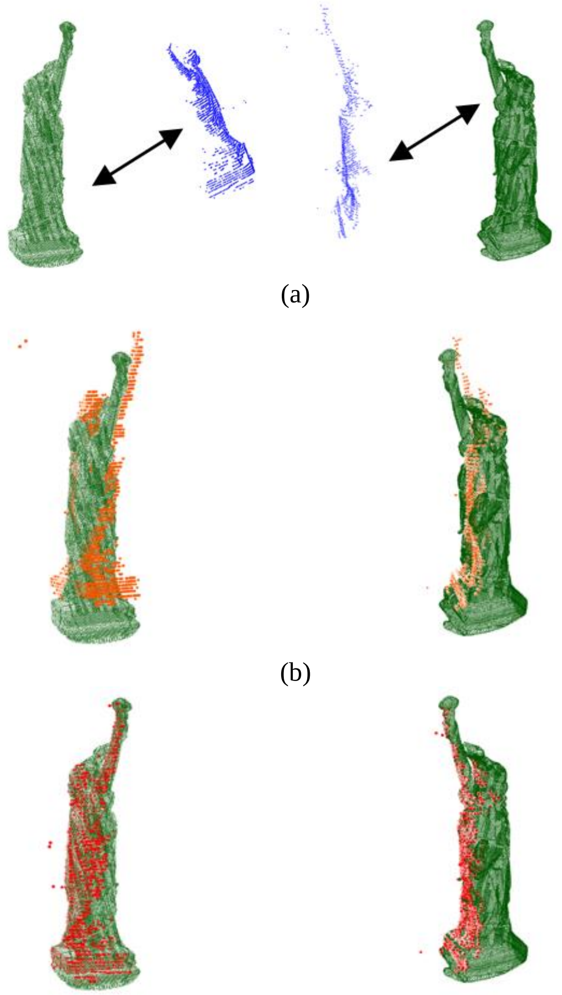
Model alignment is composed of initial rough alignment and refinement. To process the initial rough alignment, first, we extract key-points from source model (point cloud of in-situ model) and target model (point cloud of the existing CAD model). Key-points are the points in a point cloud that are stable, distinctive, and can be identified using a well-defined detection criterion.

For each key-point of both models we calculate feature values which describe the local geometrical properties of the model. Based on the sampled feature values, the source model is aligned with the target model with a transformation information of the source model to the target model. Finally, we refine the transformation using all position of points of both models.

2.3 Test results

We tested the alignment between laser scanned 3D mesh model and a single scanned frame as shown in Fig.

2. Fig. 2. (a) is the initial position of both models. Fig. 2. (b) is an initial rough alignment result. Fig. 2. (c) is a final refinement result. We extracted key-points from both models by uniform sampling and used Fast Point Feature Histograms (FPFH) local feature descriptor [3] as a feature of each key-point. Initial alignment was performed using Random Sample Consensus (RANSAC) [3], and Iterative Closest Point (ICP) algorithm [3] was applied for the final transformation refinement.



(a) (b) (c)

Fig. 2. Alignment test results. (a) Initial conditions (b) initial rough alignments (c) refined alignments

3. Conclusions

In this study, we designed an environmental information feedback framework for the cutting operation in the dismantling of nuclear facilities. And we tested alignment algorithm using 3D laser scanner and point cloud processing algorithms. So far we implemented test bed for only alignment of in-situ model and existing model, In the future we plan to implement CAD model update algorithms which will change the existing model based on acquired mesh model from the laser scanned point cloud.

ACKNOWLEDGEMENTS

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