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An Experimental Trial of 3D Synergy Modeling from X-ray CT and Neutron Radiograms

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The synergy imaging is an imaging technique which obtains a nuclide distribution image with higher spatial resolution using the differences between cross sections of neutron and X-ray [1]. The concept of the synergy imaging is developed from the image alignment technique using the mutual information (MI). In our previous computer simulation study, the procedure extended to the three-dimensional (3D) nuclide mapping. For making a 3D volume model, we assumed the use of X-ray computer tomography (CT) technique, and the neutron radiograms which were taken along only orthogonal three directions. The 2D synergy imaging were carried on along the proper three directions between neutron radiograms and reconstructed X-ray radiograms from the CT model. Obtained nuclide distribution results for three directions were reconstructed by the back projection method and obtained the 3D nuclide distribution by analyzing the voxel data after the back projection. This procedure has a great advantage for the 3D model construction with neutron, because the number of the neutron radiogram measurements is reduced greatly.
In this study, we applied this 3D synergy imaging method to an actual object and demonstrated the 3D voxel model reconstruction of the nuclide distribution using the procedure. The sample object was an aluminum cylinder of 20 mm diameter and 10 mm height including metal wires of Ta, W, Pb, In and Ag. The X-ray CT measurement carried on the laboratory system with 150 keV micro focus generator. The neutron imaging was taken at Hokkaido University Neutron Source (HUNS), Japan. The neutron detector was GEM type with spatial distribution of 0.8 mm. The sample was set on just before the detector window to eliminate blurring. For the case the neutron radiogram size has only 25 x 25 pixels. From the X-ray CT measurement we pulled out the appropriate images which coincided with the neutron measurement directions, and proceeded the synergy imaging to obtain the nuclide distributions. The resulted 2D nuclide distributions were very coarse because of the statistics of the neutron radiograms, then we averaged the each area where the shadow of each wire was recognized. The results obtained were able to distinguish each nuclide. Finally, we reconstructed the 3D voxel model by the back projection of three nuclide distribution images from the three orthogonal directions. The obtained 3D model has the higher spatial resolution equal to the X-ray CT voxel and correct nuclide information of wires. That is, it can be said that 3D synergy imaging was successful.
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[1] H. Hasemi, T. Kamiyama, H. Sato, K. Kino, K. Nakajima, NSS/MIC/RTSD Workshop 2016, (2017) 10.1109/NSS-MIC.2016.8069786.

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