Super Resolution via Deep 3D Convolutional Networks for X-Ray Computed Tomography of Microstructures

Tomoki Komiya[1], Yukie Nagai[1], Yutaka Ohtake[2], Akira Monkawa[3], Yuka Miura[3], Tomoko Gessei[4]

[1]Graduate School of Systems Design, Tokyo Metropolitan University, Japan, [1]The Research into Artifacts Center for Engineering, The University of Tokyo, Japan, [1]Commercialization Support Department, Tokyo Metropolitan Industrial Technology Research Institute, Japan, [1]Research and Development Department, Tokyo Metropolitan Industrial Technology Research Institute, Japan

In recent years, expectations of savings in materials and costs in product manufacturing have drawn attention to microstructures. Microstructures consist of repetitive patterns of small structures and can be manufactured via additive manufacturing technologies. However, defects such as voids and fractures between layers generated during manufacturing may reduce the advantageous physical characteristics of microstructures, such as their stiffness and thermostability. One way to examine an object with a complex inner structure is to scan the entire object, including its inner structure, using X-ray computed tomography (CT). With X-ray CT scanning, a volumetric image including the inner structure can be obtained in a non-destructive manner. However, there is a trade-off between the field of view and the resolution of a CT volume. If an object is scanned with high resolution, only a part of the object can be captured. Conversely, scanning the entire object at once results in a low-resolution CT volume in which the defects are no longer recognizable. In general, a quality inspection requires that the CT volume of an entire object be at high resolution. In this study, we propose an algorithm to increase the resolution of a CT volume of an entire object using a machine-learning method. The algorithm first trains a convolutional neural network using a dataset consisting of pairs of part of a high-resolution CT volume and the corresponding part of a low-resolution CT volume of the same object. After training, taking a low-resolution CT volume of an object, our algorithm generates a CT volume with nearly two times higher resolution than the original CT volume. Using experiments, we show that defects can be recognized in the resulting high-resolution CT volumes.